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SCHOOL SCIENCE AND MATHEMATICS

FOUNDED BY C. E. LINEBARGER

A Journal for all SCIENCE AND MATHEMATICS TEACHERS

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Adapting the Curriculum to Our Era

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXXVII APRIL, 1937 WHOLE NO. 321

MR. FRANKLIN'S DEATH

March 16, 1937.

The many friends of Mr. George T. Franklin will be shocked to hear of his untimely death which occurred on February 3, 1937. He was an active member of The Central Association of Science and Mathematics Teachers and was at the time of his death a director as well as the chairman of two important Association committees. Mr. R. E. Davis of the chemistry department of Lane Technical High School in Chicago writes in part. "Mr. Franklin died very suddenly February 3. He had been in good health, but on the morning of the 2nd he phoned me saying he was not well and was staying at home that day but would be back the next day. It was certainly a shock to us for he had been at Lane for fifteen years and we depended much on his judgment and ability." The following is a statement sent by Mr. Davis which briefly tells of Mr. Franklin's career.

George T. Franklin died Feb. 3, 1937 at the age of 54. He was born in Grayson County, Kentucky, where he lived until he was of age. He attended the Southern Kentucky Normal School at Bowling Green, and after his graduation there taught in Kentucky, New Mexico, Colorado, Iowa, and Indiana. He came to Lane Tech in Chicago from the Whiting Indiana High School in 1922.

During the time while he was teaching he did graduate work at the University of Colorado and the University of Chicago. His work as a teacher was marked by his thoroughness and his painstaking care. He contributed a number of articles to *School Science and Mathematics* and to the *Journal of Chemical Education*. He served as President of the Chicago Chemistry Teachers Association and as Chairman of the Chemistry Section of The Central Association of Science and Mathematics Teachers. At the time of his death, he was a member of the Board of Directors of the Central Association.

Mr. Franklin never married, but he is survived by three brothers and four sisters who live in California, Colorado, and Kentucky.

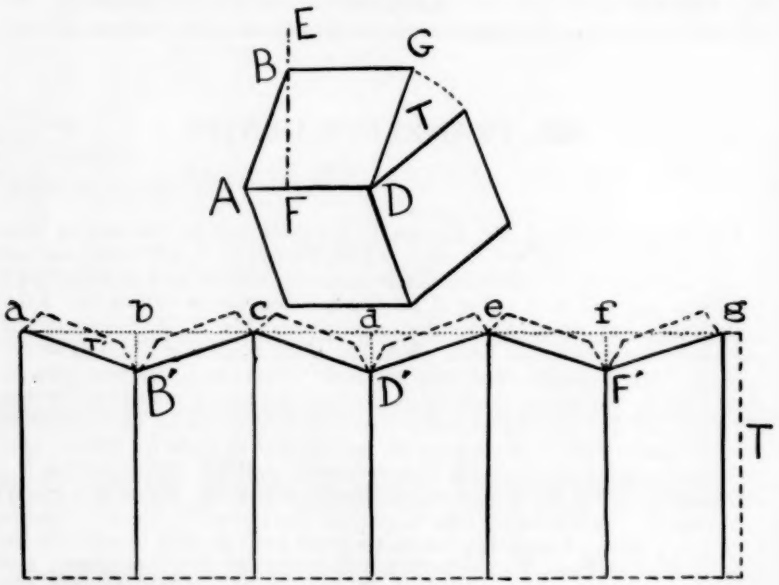
HAROLD H. METCALF,
Secretary of the Association.

CONSTRUCTION OF A HONEYCOMB

By Louis Vogel
The Buckingham School, Cambridge, Massachusetts

In teaching the life history of the bee to third and fourth grade science classes, it was found that the construction of a honeycomb afforded desirable pupil interest and activity.

Each pupil was given a sheet of fairly stiff paper on which had been multigraphed the pattern for a bee cell as shown in



Directions for making a pattern of a bee cell:
Take $AD = 1\frac{1}{2}$ inches.
Lay off $AF = \frac{1}{2}$ inch.
Erect $EF \perp AD$.
Construct $AB = AD$.
Complete rhombus $ABGD$.
Repeat three times, as indicated.
Make a developed hexagonal prism with sides ab, bc, etc. $= BF$. Construct aB', $B'c$, cD', $D'e$, etc. $= AB$. Cut away angles $bB'a$, $bB'c$, etc. Leave tabs (T') for fastening.

the accompanying diagram. The pupil cut out the figures, folded them and pasted the tabs (T and T). The bases were then slipped into position within the side walls (B at B′) and held by pasting down the tabs (T′). The cell could then be studied and admired for its strength and symmetry.

After the individual cells had been studied they were pasted together to form a section of honeycomb. This artificial and enlarged comb was compared with the natural product. The pattern formed by the hexagons was noted, and the interesting surface formed by the three-sided (trihedral) angles of the bases was found to be just like the commercial comb-foundation used by bee keepers to accelerate and control the comb building of the bees.

In the third grade the pupils, guided by charts and blackboard diagrams, made drawings of bees' eggs, larvae, and the three types of bees, workers, Queen, and drones. These drawings were colored, cut out and placed in proper positions; eggs in some cells, larvae in others, and in the rest, yellow cellophane to represent pollen and honey. Wings of cellophane marked with veining were glued to the paper bodies of the bees, and the bees were attached to the comb to create a very creditable picture of the life in a bee hive.

In the fourth grade the class was more interested in making charts showing the life history of the bee than in the paper cutting activities.

INVITATION TO INDIANA

The Indiana members of The Central Association of Science and Mathematics Teachers will have a spring outing at Brookville in beautiful Southern Indiana Saturday May 15, and this is your invitation to come and enjoy the day with us. Indiana scenery, Hoosier hospitality, spring weather and God's outdoors—that combination should be sufficient to tempt you to come a long, long way to be with us. We meet at Matemora north of Brookville at ten o'clock in the morning. From there we go together into a two hundred acre virgin forest, over the hills and far away. Geology, geography, botany and bird study with competent guidance. At noon we eat in the open whatever we have brought in the lunch basket. You can cook in the open if you wish. A number of folks from the high schools and Butler University of Indianapolis are definitely planning to go, and we confidently expect a lot of the Cincinnati people to join us; besides, we hope to have a number of friends from other towns in Indiana and Ohio. If *you* can come, you will find our hands warmly extended in welcome. Dinner in the evening in historic Brookville for those who can arrange to stay. Friends, if you don't come, it's your loss and our deep regret.

THE INDIANA MEMBERS

When you change address be sure to notify Business Manager W. F. Roecker, 3319 N. 14th Street, Milwaukee, Wis.

CONSERVATION AND COLLECTIONS

By Hazel Seguin
State Teachers College, Superior, Wisconsin

We have come to a time in our history when we should stop collecting nature's treasures. Today adults have the habit of collecting strongly developed. When they go on a trip they feel that they must collect bits of this, pieces of that and bring them home to prove to their neighbors and friends that they have actually been places. In the spring, summer, and autumn, how many cars coming from week-end trips in the country are laden with spring blossoms pulled up by the roots, with trees, mosses, plants, and autumn leaves? Nine times out of ten these treasures of nature become a burden as soon as they are brought into the home. It is too much trouble to transplant them, as had been the intention when they were gathered, or even to arrange them in vases. Consequently these choice bits from our woodlands are merely thrown away.

I believe we, in our teaching, too often foster and develop to the fullest in our children the desire to collect. Do you, in your school building, have collections of leaves, of pressed flowers, of insects, of stones, which were assigned as each child's part in a lesson? Are these chucked away in cupboards or on shelves to gather dust and never to be used again?

To have in a school museum fine collections which are used as teaching aids is one thing, but to encourage each child to collect, to gather his own samples is another thing. If we start children out with the idea that they can't possibly enjoy the flowers, leaves, insects, or rocks until they get them home and in a box or pressed in a book and until they have many, many of them together, are we fostering the kind of adult conduct we are preaching and hoping for in our teaching of conservation?

In the past, haven't we been just a little bit too exhibit conscious? Haven't we, too often, made exhibits for exhibits' sake and collections for collections' sake? Perhaps we wanted them to show off to our supervisors and parents. We've made the exhibit or the collection our aim and objective rather than treating it as valuable only in so far as it bears on a problem, or leads to other interests.

It is natural for children to gather and bring things into the classroom, but is it not the adult who gives him the idea of a collection, of getting as many as he can for himself alone?

Couldn't we rather give him the idea of seeing as many as he could in the field, in their natural environs, of enjoying them there, of letting them stay there for all the world to enjoy and to see in their natural habitats?

We lose the real meaning, the real significance of anything when we collect it, whether it be living or non-living. It then becomes merely an object. In his Journal, Ralph Waldo Emerson records under the date May 16, 1834, an experience of this type. He says: "I remember when I was a boy going upon the beach and being charmed with the colors and forms of the shells. I picked up many and put them in my pocket. When I got home I could find nothing that I had gathered—nothing but some dry, ugly mussel and snail shells. Thence I learned that Composition was more important than the beauty of individual forms to Effect. On the shore they lay wet and social, by the sea and under the sky."

In teaching an isolated thing, we are too apt to be teaching merely an object lesson without giving the full significance of the object's surroundings and its place in the balance of nature.

I wonder whether in our handling of the situation where a child brings something into the classroom, we couldn't do more for him and for society by finding out what interested him in the object he collected and open up a new vista of information for him instead of urging more collections. How many of us, upon receiving a collection of stones from a child, exclaim over them, thank the child, and put the collection in a prominent place, thus giving the other children the idea that Johnny has done something quite wonderful by bringing in the collection?

Might we not, instead, emphasize the fact that it would have been more wonderful for the child to have discovered these along the roadside or hillside and left them in their natural position, and then to have come and told us about them and if possible have led us to see the stones in their natural surroundings? Seeing the stones in their natural environment gives the children, without their being conscious of this fact, a new insight into composition, structure, texture, color, fracture, cleavage, striations, surface effects produced by wind and water, relative weight, hardness, fragibility, transmission of light, basis of origin (whether it is igneous, sedimentary, or metamorphic rock). Following this may come an interest in formations such as veins, pockets, outcrops, mines, quarries, etc. After all, aren't these the interests that we want to leave with the child, rather

than the interest of collecting and labeling so many stones? Rather than giving him the idea of collecting, give him the idea of conservation, of leaving nature's treasures where we find them, among their natural surroundings.

The aspect of children's appreciation of the woods which we want to foster most is their willingness and desire to leave an especially beautiful thing undisturbed, in its natural setting, that others may enjoy the same impression and that extermination of something whose appearance is growing rare, may be prevented.

Far too many of us still assign or at least praise collections of leaves. Can conservation be taught by collecting? By making these collections does the child not lose sight of the value of the tree in its entirety? Does he become aware of types of growth and development? Does he get some realization of the depth, spread, branching and size of roots in relation to the development of the part of the tree above ground? Is he cognizant of the trees which have been uprooted or whose roots are exposed, of the effects of crowded conditions and other interferences of exposure, of inundations, of blights, etc.? Does he get a full appreciation of the long, steady growth of the tree?

Shapes of leaves present a diversity that has apparently no end. Children are interested in these beautiful and varied shapes. But can we teach the advantages of, the benefits to different types of trees of the different shapes, sizes, textures etc., of leaves without viewing the tree as a whole and as a part of its natural habitat?

Why not teach the children to feel the necessity of studying and admiring the trees, flowers, etc., in their natural habitats? Teach them to think of them as treasures which lose all their value when we pick them, dry them, and keep them in our school or home cupboards. We've reached the saturation point in making collections. We Americans have been very wasteful. We must begin to say to children, "Do your collecting by looking at it; collect impressions and information—not objects!" We teachers must change our ideas about collections, for to foster collections is to contradict conservation. It is not helping children to get a concept of their world as a whole, to interpret and appreciate their environment as a whole. It is not making them conscious of the larger values of our heritage. Let us practice what we preach and forget collecting!

A SCIENTIFIC TABLEAU

Presented by clubs affiliated with the Illinois Jr. Academy of Science

WRITTEN AND DIRECTED BY

GLENNA A. SPENCER AND MABLE A. SPENCER

The reader, boy and girl are dressed in modern clothes. The reader presents her prologue.

The curtain opens to a simple shallow stage with a plain drop or curtain at the back.

Since this Tableau presents families of diversified fields of science which lived in different generations it should be given in Acts. The curtain is drawn after each family.

The setting for the Herschell family: A simple telescope made of dark cardboard and mounted on a pedestal. William stands near telescope and Caroline is doing calculation work nearby. John enters later and stands near his father. Caroline and William are dressed in costumes of the year. John represents a generation later.

The Curies: A simple laboratory. Madame Curie a woman of about thirty-five has long hair, is simply dressed in dark clothes adorned by a white collar. Pierre about the same size as Madame, serious face, goatee. Irene Curie Joliot and her husband are dark and charming. Dressed in modern French clothes.

The Wright Bros.: A bicycle shop. A work bench of some kind, with sample glider and airoplanes and bicycle parts. The brothers may be seen behind a bench or near a broken bicycle. Cap and trousers; no coat or necktie, detachable collars on shirt as seen on the clothes of 1915.

(*Reader comes in front of curtain*)

Greatness is rare in the individual but far rarer than a great individual is a great family. For that reason we have chosen from the eminent men and women of science, three famous families who have contributed to practically every scientific field and who have touched the lives of all people.

HERSCHELS

For ages man has viewed the heavens with a feeling of curiosity mingled with awe. The ancient man could scarcely understand his position with respect to the earth. The celestial bodies were far beyond his ken. With them he associated the myths and superstitions which were passed down from generation to generation because of the apparent association of certain heavenly happenings with human catastrophes. He set the sun up as a god and worshipped it. He never dreamed that before many generations had viewed the marvelous feats taken place in the firmament, there would develop sufficient scientific understand-

ing to enable man to set up instruments which might be used to see the actual movements of the heavenly bodies, nor did he realize that it might cause man to work out a universal plan which would enable him to understand the things of the present, to explain things of the future.

(*Curtain opens to show William, Caroline, and John Herschel*)

Any one of the three characters here shown would have contributed enough to make the name of the Herschel family forever remembered among astronomers. From a family famous for its musicians came William and Caroline Herschel. For years they intermingled their profession, music, and their obsession, the making of telescopes. The funds they obtained from their music were used to defray the expenses of building telescopes. Between this popular brother and rather quiet sister, there developed a splendid working companionship almost akin to devotion. She, no less than he, worked night and day to satisfy their insatiable longing for a better view of the heavenly bodies.

Boy: Why did they have to work so hard just to view the stars?

Reader: They had to make their own telescopes and they sat for hours at a time grinding away the lenses.

Boy: I think I remember that he discovered the planet which is now known as Uranus. Is he the one?

Reader: That was probably the crowning achievement of his career, although many of his other works were more important to astronomy itself. He studied the sky section by section, night after night, and discovered that even the twin stars had a certain movement with respect to each other. The orbits were studied and both Caroline and William became interested in the mathematical aspects of astronomy.

Boy: What preparation had he for mathematical study? I thought that the mathematics of astronomy was very difficult.

Reader: It would probably interest you to know that his first steps in the study of astronomy came from a study of mathematics which he was making as a preparation for some advanced work in music.

Boy: Who was the first person to recognize and reward the work which he did?

Reader: King George heard of his work; came to be very much interested in him. He made William His Majesty's as-

tronomer, giving him and also Caroline sufficient allowance to make them free of other obligations and to help them to establish quarters for their work.

Girl: Why should she be given a salary?

Reader: It was early in their careers when people realized that without the painstaking assistance of his sister, Caroline, that the great astronomer could accomplish only a small part of his observations.

Boy: Did Mr. Herschel or his sister ever break up this partnership by marriage?

Reader: The answer to that question could be either yes or no. At about fifty years of age Mr. Herschel married a very wealthy widow whose position, financially and socially, was a very great help to both him and Caroline. They developed a very deep friendship and mutual respect for one another and the work of Caroline and William was not in any way interrupted by his marriage.

Girl: Who is the younger man we see here?

Reader: This is the son of William, who was born in the very atmosphere of science and lived to maturity in the presence of the world's most renowned and industrious astronomers. One would expect him to be interested in his work. He was splendidly educated, financially independent and intellectually capable of continuing the tremendous task which his father had so masterfully undertaken.

Boy: After his father had studied all of the heavens so carefully, what was there left for him to do of importance?

Reader: In the first place he decided to study farther the twin stars which had received much attention during the later years of his father's life. He then decided to go to the Southern Hemisphere and study the stars.

The history of this family would extend down at least another generation for among the children of John Herschel are two whose names stand out for scientific achievement: Alexander Herschel, whose work in meteoric astronomy is outstanding, and John, who was recognized for his work with spectroscopic investigations on the southern nebulae.

(*Exit on curtain*)

Boy: Was John Herschel, senior, honored for his work?

Reader: Yes, he received all distinctions, was given a title, awarded the Medal of the Royal Society and was very popular

among the scientists of his time. His greatest treat was probably the fact that he happened to be where he could view the return of Halley's comet in 1833.

The satisfaction derived from a successful scientific investigation was his greatest reward. He carried out the dreams of his aged father and gave to the world the wealth of maturity and intellectual richness which he inherited.

CURIES AND JOLIOTS

(*Curtain Monsieur and Madame Curie*)

This couple which appears before you represents one of the most celebrated of all scientific families and one of the most industrious and modest. This is a family of noble characters, earnest, capable, brilliant, yet possessing all of those human characteristics which make for life's greatest fulfillment. The most worthwhile characteristics of two nations were fortunately blended together into what promises to produce the world's most richly endowed scientific family.

First Student: From what two nations did these people come and who are they?

Reader: The lady is Madame Marie Curie, who came from Poland and had the love for art and nature so common among her people. The gentleman is Pierre Curie. He was a native of France and it was in Paris that they met.

Second Student: Why did Madame Curie leave Poland?

Reader: She was a daughter of a Professor of Physics, by the name of Skaldowska. Poland was at that time in the hands of the Austrian government. She was a part of a radical movement and was too outspoken to be allowed the freedom which she wished. She left Poland and finally decided to go to France where she might continue her studies. She had only her courage and intelligence between her and starvation.

First Student: What did they do that was of such great value that they should be chosen as one of the three great scientists to be represented here?

Reader: Madame and Pierre Curie discovered radium and after many months of labor with crude equipment and limited funds they extracted minute quantities of radium bromide.

First Student: Did they always have to work with such a limited income or did people finally appreciate their true worth?

Reader: They soon were recognized, for in that year, 1903, they were awarded the Nobel prize and with it they received

a rather liberal money award as well as world wide distinction.

(*Exit Pierre Curie*)

Second Student: From whom did this money come?

Reader: Alfred Nobel, the man who made dynamite, left this money in trust so that worthwhile people might have means to carry forward the work they wished. The Curies used this endowment as Nobel would have wished and thus made their researches more fruitful. Again in 1911 Madame Curie was awarded the same prize but in a different field.

Second Student: Had Pierre Curie stopped work?

Reader: Oh! I forgot to tell you that a very great sorrow had visited the Curie home. Pierre Curie had been very suddenly killed by a dray in the streets of Paris. Madame Curie was again left with her own responsibilities, but this time she had two children to support, Irene who was eight years of age and Eve Denise who was just two.

Second Student: How did Madame Curie support her children by herself in a country which seldom recognized women?

Reader: The death of Pierre Curie came at a time when the memory of his world renowned honor was so recent that an exceptional decision was made. It was decided to give Madame Curie the position which her husband had occupied but a brief year and one half before his death.

First Student: What has happened to Madame Curie since that time?

Reader: Madame Curie lived to see the fruition of many of her greatest dreams. She saw her work accomplish marvels in practical work as well as in scientific theory. She was famous in her own behalf, she contributed without stint, without regard for her own health. Her finest rewards, and she has had many highly coveted honors, were the children which she reared. These alone would have been satisfying. The (*Enter Irene and Jeane Frederick Joliot*) splendid motive power of her shy Irene and her equally modest husband, Jean Frederick Joliot, were rewards which gave her daily pleasure. Proud, indeed, would she have been had she lived to see them awarded the Nobel prize in 1935.

First Student: What happened to the other daughter?

Reader: Eve Denise is not inclined toward the realm of physical science but instead she loves music and is a successful musician.

Second Student: Did the Curies ever take a prominent part in the social life of their country?

Reader: No, their motto has at all times been "things before people." At all times they have avoided the social contacts and personal aggrandizement which has ruined so many promising lives. They have had a beautiful family life which has made them need few other friends. Their friendships have been simple and worthwhile, being mainly with people having the same interests and equal enthusiasm.

Second Student: Did any of them ever come to America?

Reader: Several years ago Madame Curie and her daughters came to America. This was a very happy occasion for the American scientists because Madame Curie had a very charming personality as well as a scientific imagination. In tribute to her greatness the women of America presented her with their most expensive bit of radium. Like all the other gifts she received it was immediately donated to where best it could serve the world—in hospitals of France. Radium promises to cure many cases of cancer and limit the development of others. The future value of the discoveries of the Curie and Joliot families cannot be measured in dollars and cents but in terms of human life and the alleviation of human suffering.

(*Curtain*)

We may best perpetuate the memories of this great family by remembering their wonderful courage in the face of discouragement. Weaker hearts would have faltered and ceased to labor long before the conclusion of struggles much less than theirs. The future holds much for us from this family. The Joliots are great because of merited worth and not by the reflection of the greatness of the parents. Even the tiny child has wisdom to offer if one may judge from pictures. Our prayer for them is that they may live undisturbed by national crises to reap the finest blessings of a full rich life.

TWO MASTERS OF FLIGHT

TENNYSON

Far I dip't into the future, far as human eye could see,
Saw the vision of the world, and all the wonder that would be;
Saw the heavens fill with commerce, argosies of magic sails,
Pilots of the purple twilight, dropping down with costly bales.
Heard the heavens fill with shouting, and there rained a ghastly dew
From the nations' airy navies grappling in the central blue;
Far along the world-wide whisper of the southwind rushing warm

With the standards of the peoples plunging through the thunderstorm;
Till the war-drum throbbed no longer, and the battle flags were furl'd
In the Parliament of man, The Federation of the world.
There the common sense of most shall hold a fruitful realm in awe,
And the kindly earth shall slumber, lapt in universal law.

THE WRIGHT BROTHERS

(*Curtain Wright Brothers*)

Boy. Oh, those are the fellows who got their start by a flying toy which their father brought home to them.

Girl: Didn't one of them sell old bones and iron to make money?

Boy: Yes, and they both ran a bicycle shop in Dayton, Ohio.

Girl: Dayton, Ohio? Why, they must be the Wright Brothers. But they don't have on goggles—not even coveralls.

Boy: No, they always dressed like that, whether they were to meet a king or fly an airship down at Kitty Hawk, North Carolina. Did you know that Wilbur Wright thought it would be a thousand years before man would fly? But that was before they built a motor driven plane.

Girl (*To Reader*)*:* Why was it then, that they went ahead and worked when they thought it would be so long and especially when they had so little money?

Reader: The Wright Brothers had scientific curiosity which kept them forever thinking about and working out their idea. It was not glory nor financial gain that goaded them on, but simply a belief that some day man could fly if he had the motive power.

Boy: How did they first attempt to fly?

Reader: They first worked with a kite. The lack of finances prevented more extensive research until in 1896 the death of Lilienthal, a European glider experimentalist, aroused a new interest. After four years of pondering and minor experiment they created the first man-sized model of the future airplane and they tested it in the air.

Girl: Were there any scientific publications which the Wright Brothers studied?

Reader: Yes, they read everything available. The data they found this way was not used blindly. They tore it apart and found its scientific truth or fallacy before they constructed any expensive apparatus from it. The fact that they were intelligent critics was shown when they proved that Langley and Maxim, both European scientists of aeronautics, held the wrong view

about balance. The Wright Brothers constructed wings perpendicular to the rudder rather than V-shaped.

Girl: From what else did they study?

Reader: They studied bird flight. From this they conceived the idea of hinged wings which could be moved alternately up and down as birds flap their wings in order to secure lateral balance.

Boy: Did they progress consistently or were there moments of discouragement?

Reader: Yes, they grew perturbed at times. Discouragement almost lapsed into complete forfeiture of further research when they were unable to get sidewise balance. However, one of the brothers rose to the intellectual occasion—Wilbur it was this time—and found, as he was twisting a paper carton, that it was warp that they needed. Once able to launch in the air with one more new adjustment it did not take them long to find that they needed a movable rudder, or tail as they called it. With the idea of air tight cloth for the wings came a complete airplane without the motor power.

Boy: When did they first fly with a motor driven plane?

Reader: February 13, 1903 they made their first test. Here, indeed, lay the principles of flight which are embodied in every practical airplane known in the world today.

Girl: Did they ever receive any commercial benefit from their work?

Reader: This came rather late. They tried to interest the U. S. government in their plane but America was not ready for the fruits of her ingenious sons. When they took their plane to Europe the Wright Brothers were accepted socially but not financially. Finally Germany became scientifically interested and purchased their planes. Wilbur, who died in 1912, did not live to reap the benefits of their full financial rewards nor the honor which even the U. S. later conferred upon them.

Boy: Why was it that the Wright Brothers were never seriously injured?

Reader: I was hoping you would ask that question. The Wright Brothers never flew unless weather conditions were favorable. And now may I tell you this before they go—the Wright Brothers were fortunate in being poor. They did not waste their time setting up expensive apparatus which had no scientific investigation behind it. Rather, they built in their minds, created in their imaginations and investigated before

they proceeded. Their separate minds worked not as a menace to each other but were used together to strike down each new idea and to build it up from the very veins of true scientific principles.

(*Curtain*)

You have had a brief glimpse of three of the World's greatest families. Their genius in each case has been accompanied by years of labor. They have each entered into the spirit of what scientists call true research and the reason for their success may easily be expressed in the words of a modern poet.

Day and night I wander widely through the wilderness of thought,
Catching dainty things of fancy most reluctant to be caught.
Shining tangles leading nowhere I persistently unravel,
Tread strange paths of meditation very intricate to travel.
Gleaming bits of quaint desire tempt my steps beyond the decent.
I confound old solid glory with publicity too recent.
But my one unchanged obsession, whereso'er my feet have trod,
Is a keen, enormous haunting, never-sated thirst for God.

GENEVA LAKE SCHOOL OF NATURAL SCIENCE
June 26–July 31, 1937

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ADAPTING THE CURRICULUM TO OUR ERA

By Anna A. Stafford
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Mathematics is a healthy tree, born out of the muddy earth, where its roots are still buried. In every intellectual era it puts forth new branches. We become so pleased with the practical value of its useful products, the pretty blossoms, and the refreshing benefits of its shade, that we are prone to forget the living trunk and roots. Then comes a time when the leaves wither, the shade disappears, the flowers are forgotten, and the unused fruit rots. Along comes a noisy army of educators always anxious for some kind of reform, crying, "Chop it down, off with its head, we've no use for this dried up stuff." There isn't a live mathematician today who has not heard some reverberations of their noise, if he has not actually been called upon to answer some of it. These misguided educators have political axes which they sometimes get ground sharp enough to do real harm.

I think the simile of the tree is a very apt one. Many of us are attracted to mathematics in the first place by the sheer beauty of it. I overheard a freshman just last month remarking to two others, "I like those problems. They are hard, but you know you get quite a kick out of it when you get one right." He is no isolated specimen, either. The number of mathematical or semi-mathematical curiosities that Ripley publishes in the daily papers testifies to the lively curiosity and interest of the general public in our subject. There are plenty of others who have no use for "fun" or "beauty." They only want to know "what it is good for." I think no one disputes that mathematics is "good for" enough things to justify its existence in the present mechanical state of civilization.

My proposition, however, is this; the tree is losing a lot of dead leaves, and it is going to lose a lot more. They are being pushed off by the newly budding leaves that are sprouting all over the realm of mathematics, education, and the physical sciences. Too many educators are focusing all their attention on the dead and dying leaves. They insist they are not worth keeping. Too many of our teachers are not aware of anything but the dead branches. We hear a great deal about curtailing mathematics requirements, eliminating mathematics. It is too

hard and too dull, and we had better give it up. Most of you know better, but the time is certainly ripe for a little stock-taking, refurbishing, and replacing. If you could go out to our smaller high schools in any middle western state (and I am not implying that the cities do much better) and take a good look at the mathematics as it is taught by the science teachers or the English teacher or the athletic coach, who has satisfied the minimum requirements to teach mathematics, or even by a legitimate mathematics teacher who can satisfy any reasonable requirements, but who hasn't stirred a brain cell since he got his last diploma, you would certainly agree with the educators in the teachers colleges, and the school superintendents who maintain that mathematics is a dull, hard, and useless occupation for our twelve to sixteen year olds.

I shall take a moment to survey the typical schedule, a year of algebra, nowadays only to quadratics, a year of plane Euclidean geometry, perhaps a half year of commercial arithmetic if the school boasts a commercial course, sometimes solid geometry, trigonometry, and more algebra. All but trigonometry and even most of that, belong to ancient history.

In Algebra we teach them to use "x" to anticipate the answer. How old this device is I do not know, but the Egyptians used it in the Rhind Papyrus, a venerable treatise on fractions, algebraic and geometrical problems, which is not later than 1650 B.C. We progress as far as using several unknowns in one problem, but we never get so far as solving Diophantine Equations, (that would take us up to the third century B.C.) with the remarkable exception of

$$x^2+y^2=z^2,$$

for which some students learn the solutions 3, 4, and 5 and even 5, 12, 13. Our course in algebra does not go so far historically as the second century. If we get as far as quadratic equations we are as advanced as the Ancient Babylonians, who, as the recent work of Neugebauer of Denmark shows, had quite adequate methods of completing the square, and plenty of ingenious tables for computing square roots. Just how up to date, then, is our course in algebra? There is no type of problem included in the course which could not have been solved by our methods 2000 years ago. The geometry we teach was all put down in much the same form in which we teach it today

in the time of Euclid, which advances us at least as far as 300 B.C. Most of it was known some centuries earlier.

Somewhere in the seventeenth century Descartes had a brilliant idea for the representation of a function of two variables on a plane surface by the use of two coordinate axes. This idea is the father of the graphs in all the algebras and in the daily newspapers. A little later Pascal and Newton perfected the Binomial theorem, but now we are leaving our strictly elementary courses. An honest survey of the material we present in two years of high school mathematics fails to show anything more modern than Descartes, and certainly fails to show any type of problem or solution not well known to the Ancients. In our four year courses we do not like to progress beyond Newton.

This is not a fair picture, of course. It is a correct picture, to be sure, but hardly a fair picture. Who knew all these things that we now teach our thirteen year olds? Only the mature scholars and the priests, surely. In those days formal education was a prize for the highly privileged. Everybody studied philosophy, which was a broad cloak embracing everything from the nature of the universe to religious dogma, and of course, whenever the nature of the universe comes up, we have need for all the available mathematics with its physical applications. We think of Archimedes, Ptolemy, Galileo, Keplar, great geniuses of science, only in those days the word was philosophy. But how about the school boy, such as he was? There is a common tale of a German merchant who, in the year about 1600, wanted to send his son to school to learn mathematics. He consulted the best authority he could find—and mind you, his son was a mature student. The answer he got was, "If you want him to learn addition or subtraction you can send him to a French or English University, but for the new branches, multiplication and division, he will have to go to Italy, because they are much advanced. (They were using arabic numerals.) Imagine going to a university to learn to add and subtract, though with the present tendency not to teach anything useful in our elementary schools we may be getting back to it! However, my point is this, and I wish to make it very emphatic. Four hundred years ago the ordinary student went to a university to learn elementary arithmetic. Today a ten year old is just naturally expected to know it. Four hundred years ago a normal child's head just could not be expected to hold all the knowledge we expect our normal ten year olds to have. There was no raving

about I. Q.s and mental ages because so few people used the kinds of brains we use. They didn't need them. They learned whole literatures, history, tradition, by rote, and memory was king. Today the styles have changed. We are slow in throwing off the yoke, but not nearly so slow in throwing off the old as we are in assuming the new. If any of you have ever seen a good mathematical library in one of the larger universities, I wonder if you read the titles of the books or looked into them. You will find hundreds and hundreds of books, and I dare say many of you have never even heard of many of the branches of mathematics represented there. The man in the street thinks that higher mathematics consists of harder problems in algebra, geometry, and arithmetic. I know, because I have asked hairdressers, barbers, porters, travelling companions on buses, trains and boats, even clergymen and school superintendents. You in this audience are more fortunate. You have heard of trigonometry, analytic geometry, and calculus. Many of you will agree with Professor E. T. Bell of California Institute of Technology that our fifteen year old would-be engineers would be more profitably and not nearly so laboriously employed in learning differential calculus as in stumbling through Book I of Julius Caesar's Gallic Wars. We are succeeding somewhat in furthering this idea, too.

Almost any elementary algebra these days has a half hearted and usually spurious attempt to introduce a little trigonometry. It is a good idea, but very badly done. Can we not fit it into arithmetic when we teach areas, if we must have it so early? And we really must have it early if we want our elementary courses to be "practical." It is a step in the right direction. What can you do to make the step less awkward?

Analytic geometry in the shape of graphs we are dragging in as fast as we can. Anybody can learn things from a well drawn graph. Do we emphasize enough the short cut to reading that it is? Just as arithmetic waited for the Arabic numerals to get anywhere, so statistics relies upon the graph to show us trends and situations that pages of written words can very easily fail to convey for the simple reason that many comparisons can be made on a graph that were not foreseen or intended by the maker. Nobody can overemphasize either, the importance of the ability to translate a functional relationship between two variables into an algebraic equation, and to see the consequences as they can be seen so readily on a graph.

How much advanced mathematics can we and should we bring into the lower courses? There is no question in your minds, I feel safe in assuming, that there are bits of our present courses that can and should be mercilessly lopped off. That is not what I intend to discuss. My aim is merely to show you the possibilities, and present some ideals to work toward, which we are as a matter of fact forced to work toward if we are alert to what is happening in the intellectual world.

How much more mathematics can we drag in to the lower levels? We are limited by four factors, I think: 1. The intellectual capacity of the student, 2. The time at our disposal, 3. The knowledge and interest of the teacher, 4. Public opinion.

How much should we? The answer depends on our aim in teaching mathematics at all. The pertinent factors I think are these: 1. Pupil enjoyment and satisfaction, 2. Immediate application to everyday life, physics, chemistry, biological and social sciences, 3. Preparation for a life work in any of these or in the fields of statistics, finance, engineering, and related branches, 4. Cultural understanding of the theories underlying the physical sciences.

It is hard to decide which to discuss first, how much *can* we? or how much *should* we? The arguments are after all very closely related, so, bearing in mind the material that we should introduce, I intend to show how much we can.

The question of intellectual capacity I feel quite sure nobody is really capable of answering, for two reasons. First, the depths of our intellectual capacity, in spite of all our intelligence tests, have never been plumbed. Maybe I. Q.s cannot be changed. I have heard recently that prehistoric man had about the same native intelligence as modern man. He certainly did not have the same intellectual capacity. With our brains as with everything else, as soon as we reach an unsurmountable barrier, somebody discovers a crack, and somehow the pioneers crawl through. Somebody enlarges the crack to a tunnel. We all rush through and forget there ever was a barrier. For example, about a hundred years ago somebody invented a steam engine that could go perhaps as fast as thirty-five miles an hour. Some of you doubtless know that there was a real concern as to whether it was practical to go so fast, because the human anatomy might not be able to withstand being hurled through space at that terrific speed. Six hundred years ago, before the Roman numerals were replaced by the Arabic, children really could

not learn to multiply. Adults did it by all sorts of queer devices. The Greeks did geometry and the Arabs did algebra because they could not handle arithmetic. Any of you who have ever read the first book of Herodotus know what a mess he made of trying to count the number of days in a man's life, in spite of the fact that he had been to Babylon and knew perfectly well how many days there were in a year. It was just too complicated a mental effort with the complicated alphabetical number system. Are the problems of quantum mechanics, non-Euclidean geometry, and relativity more muddled in your minds today, than the problem of multiplying 70 by 365 was to Herodotus? It you think so, I am sure you have not read Herodotus.

Granted, however, that we must stop in our logical development of mathematical theories because of mental deficiency, partly because of immaturity but mainly because we cannot, at this stage of civilization, teach some things in such a way that adolescents can learn and appreciate and understand them. Some of us think much good work has been done in leaving such things as proofs of incommensurable cases out of elementary geometry. Some people are sorry to see rigorous proofs banished, but they can be banished in the right way. What we lose in one place we gain in another, and no harm is done. The same is true of the theory of limits in geometry, and various places in algebra wherever it arises prematurely. Who would want to teach children the theory of extracting cube roots, when they all go to school long enough nowadays to learn to use logarithms?

Second, much of the mathematics that is elementary enough to teach at the lower levels, is ignored completely because it does not come in as a logical or historical necessity in the courses as we have them today. To be specific, consider probability, as ordinarily given in a 12th year course. All the preliminaries that are needed are permutations and combinations. It is a separate part of mathematics that could be stuck into the course almost anywhere. I am sorry I have never had an opportunity to discover whether there was a stage at which children were too young to learn it. Another thing that we put into the course almost anywhere we want to is the determinant. I happen to know from experience that classes of twelve and thirteen year old high school freshmen, with I. Q.s ranging from 100 to 110, can solve simultaneous equations by determinants up to

the fourth order, and think it is a lot of fun, because a long mechanical process successfully carried through does actually give a great deal of satisfaction. Students in third semester algebra who have never seen the inside of a solid geometry book can understand the relationships of the various "conic sections," and if we gave a third semester of high school geometry I have no doubt they could learn all the classical constructions of those curves, as well as most of the content of our courses in analytic geometry. Here we are definitely limited by the time at our disposal. Perhaps it is just as well. I need not dwell on that. Many of you, I hope, are aware of the movement to give a completely revised six year mathematics course in the schools, beginning in the seventh and ending with the twelfth grade—in the meantime we can do a good deal with the present two or four year course.

Number theory is a fascinating field, reserved for no very good reason for graduate students. Yet number theory and Diophantine equations are the most popular branches of mathematics.

The most serious drawback, of course, is our inability as teachers to present the modern developments to our students in a manner that they can be expected to understand. I feel quite safe in saying that a large per cent of the high school teachers who really know more mathematics than is to be found in the ordinary text books they are actually teaching are to be found right here in this Association. I am one of the first to admit that the mathematicians who know and could explain the modern developments, are the last people willing to do so. Even the mathematical journals that start out with the avowed intention of popularizing mathematics soon become too technical for any but the expert to read. The only really popular expositor of mathematics that I know is, believe it or not, Ripley, who entertains the public about every third day with a magic square, or some other mathematical curiosity. You and I would do well to take the cue from him, and at least once a year read thoroughly some one of the many treatises on mathematical "recreations," because it is in such books that, *believe it or not*, such subjects as statistics, probability and so forth, get their first and hence simplest publication. Many a respectable field of mathematics began life as a "curiosity." It is the most fruitful and painless way that I know to arouse the intellectual curiosity of the teacher and—if he has any—his good pupils. I

have compiled a list of all the ones I could think of or get hold of in the last few months. Some are out of print, but many of them are available in libraries. I prepared the list because I have often been asked by teachers for just such a list of books that they could put into their libraries on the mathematics shelf that would be interesting and useful. The list would be better if I had not resolutely excluded the excellent books in German.

I have mentioned public opinion as a factor that determines how much we can teach our children. Public opinion has been the force at work to eliminate the long assignments of "home work" that once harassed our seventh and eighth graders not nearly so much as they did their parents. I don't pretend to be a psychiatrist, but I have cured many a bad complex in good students whose minds actually become blank with panic the minute they are confronted with a page of what they call "Written Problems" or "Sentence Problems." Almost invariably, if the student is a good student in other respects, and often if he isn't, he finally admits that it is true that there were scenes and tears at home because he couldn't do his home work, and mother or dad couldn't either. It works the other way, too. If a mediocre student is better at "sentence problems" than his drill work would indicate, it usually means that mother was a teacher before she got married, and did a good share of what the regular teacher should have done. The educators yielded to the force of public opinion. In this case, I think everybody gained for it.

However, the voice of public opinion works slowly. We would not have it otherwise, because so often the loudest voice we hear isn't really public opinion. Right now a not too casual survey seems to indicate that the public has a profound interest in and curiosity about mathematics, and I may add, a reverence for it. I call to witness the proportion of mathematical problems in Ripley's cartoons, and the proportion of simple algebraic problems that you can hear on almost any "Man in the Street" program on the radio. In fact, I felt the influence of the "Man in the Street" a long time before I realized just where these sudden spurts of interest in my algebra classes came from. Those things stick in people's minds. I overhear conversations most unexpectedly in buses and street cars that make me prick up my ears in more ways than one. The man in the street has an acute appetite for mathematics which we

teachers are not satisfying. I bring you two more witnesses, dollars and cents witnesses. The first is the totally unexpected sale *to the public* of Professor Logsdon's book "A Mathematician Explains." It is the compiled lectures on mathematics given in the General Courses at the University of Chicago. It is not the kind of book you expect the public to get excited about, but it is selling. When a news company orders twelve dozen copies you know it is not for any altruistic notions about aiding the cause of science. People want to read that book. My second piece of evidence is a half page advertisement on the back of the magazine section of a conservative New York Sunday paper recently, for a set of five books, arithmetic, algebra, geometry, trigonometry and calculus. You all know the type of thing I mean. Send no money, pay the postman, and examine for a week at no cost. People want that badly enough to part with $2.95 or $3.95, or whatever the set cost. I saw a similar set last year. A young radio repair man who doubtless makes about $15 a week asked me to look them over and see if they were worth what he had paid for them. They were cheap books on cheap paper, bare but simple outlines of the courses, really not very bad. I wonder if all of you give a better introduction to those subjects? Whether he did anything with them I do not know. The significant thing for us is that he wanted them badly enough to pay for them out of his small salary. Need I mention the popularity of the purely mathematical exhibits at the World's Fair in Chicago? Personally, in spite of several visits, there were some exhibits that were so popular that I never succeeded in getting near enough to really study them. Need I mention the insatiable curiosity the American public exhibits concerning the movements of Einstein? In a summary of the scientific proceedings of the recent Harvard Tercentenary the reporters filled twice as much space with the personalities of mathematicians as with all the other physical scientists combined.

Now what are we, the people who have all that knowledge locked up in our heads, doing to satisfy this hunger? I shall tell you one thing we are doing. We are sitting back in our chairs and listening to a lot of lectures by the exponents of the latest educational fad who say "down with everything but social sciences." Consequently we give the public less instead of more of what it is asking for, and if like Marie Antoinette we all lost our heads, I mean jobs of course, we have surely ourselves to blame.

I think I have answered the question "how much can we teach?" I should sum it up in these words: the public will stand all *we* know how to give it, provided we are not didactic and make some effort to present the material in form suited to the mental ages of the pupils. Our only problem is to rescue enough time from the school schedule to do ourselves and our subject justice.

How much can we teach as far as content is concerned? In other words, how much should we try to teach, even though we are well aware that our ambitions cannot be realized in the present curriculum? I am emphasizing only four points, which I repeat: 1. Pupil enjoyment and satisfaction, 2. Immediate application to everyday life, physics, chemistry, biological and social sciences, 3. Preparation for life work in any of these fields or in the fields of statistics, finance, engineering, or related branches, 4. Cultural understanding of the modern theories of the structure of matter, space, and the universe.

First, let us certainly teach them Algebra, at least through quadratics, not because it is important to be able to factor or to add complex fractions, but because we need to understand the number system, and its properties. Let us have methods, not senseless drill to keep them busy until the bell rings, but enough drill so that every child can really handle numbers, which are more and more becoming the "language of science," not only the physical sciences, but the physiological and psychological and social ones as well, whether we like it or not. Need I suggest that this should be completed by the ninth grade?

In this generation surely every one should be aware of some of the simpler implications of the theory of probability, if only to make him conscious of the benefits and abuses of insurance.

Statistics and the theory of investments seems to be more properly the sphere of economics than mathematics, simply because the mathematical theory does not seem to interest many mathematicians. It is a fascinating field that we pass over very lightly, and yet the results of the recent "forecasts" of the election show clearly that the public is conscious of the failings of statistics. Mathematicians ought to explain why.

We ought to teach some theory of dimensions and units. By this I mean, really, the things usually considered in a chapter on "variation," which is at present, I suppose, the least palatable and at the same time, the most important and most immediately useful chapter in any text book on algebra. All we

teach nowadays is a little old fashioned "denominate numbers" in arithmetic, and the woeful result is that physics courses are becoming more and more emasculated, more purely descriptive because students cannot handle the dimensions of anything so complicated as acceleration or specific heat. Our young people have positively no conception of the universal importance of such simple relations as the inverse square law, or a direct square law which would give them the proper respect for what a deadly weapon the moving automobile is.

I put in a plea for number theory because of its intrinsic interest. Mathematics can satisfy the appetite that leads many people astray into the realms of astrology and numerology. Why cannot we let the children make tables of prime numbers and discover their properties? I have set plane geometry classes hunting for Pythagorean numbers. I find many students using simple methods of the theory of numbers to solve "sentence problems" involving integers in spite of the purely algebraic methods given in their books. Mathematicians find that the properties of pure numbers fascinate the general public more than any other kind of mathematics.

Here I add a plea for such mathematical recreations as magic squares, the three impossible problems of antiquity, paradoxes, and those fascinating mathematical pastimes which are such good training in logical thinking, and of which the public would be entirely unaware if the popular news sheets were not good enough psychologists to give the public what it wants.

I do not put in a very strong plea for cosmology, but modern geometry I think we must incorporate in the near future. The chief benefit that most students derive from the course in plane geometry is not so much the actual information contained in the propositions, as the training in logical thinking. That is Euclid's real contribution. It is worth keeping. But, let us extend the contents of the course. At present we teach two types of transformations, the size preserving, and the shape preserving, that is, equality and similarity. It is only a short step to perspective and projective transformations. The material is not intrinsically difficult. We could investigate the properties of spheres and anchor rings and one sided surfaces. I asked a group of engineering students what they thought they should have learned in high school mathematics that they did not learn. I got two answers, one was "solid geometry," the other "a little calculus." The year's course in geometry which is all most

students get, ought to include some solid geometry, three weeks would be plenty. Then the course in solid geometry could be eliminated altogether, as in practice it so often is, and ought to be. We should at least tell our students that all geometry is now divided into three parts, of which Euclidean is only one.

Every teacher should be prepared to bring up the subject of limits, infinite series, and infinitely large or small quantities when his or her pupils require it. Of course in a good twelfth grade course it is no longer possible to avoid these subjects.

We must go beyond determinants and even teach a little about matrices to our students, who expect to go to teachers colleges and read modern psychology, or to people who intend to study modern physical theories.

I need not ask for the Binomial Theorem, but I do need to ask for its applications to probability, Mendel's Law in biology, and for the simple expansion of "e" it gives, so useful in growth curves, probabilities, and interest.

I teach a great many would-be engineers these days. It is a marvel to me that they have not learned long since to use logarithms and slide rules, especially as it is hard to find anyone so dull that the use of logarithms for straight computation is beyond him. I do not refer to the refinements of their use in exponential equations. What happens is that the neglect of their mathematical training has to be made up in the "orientation" course they are all required to take. It takes one lesson to turn them all into inveterate slide rule users.

How much can you do about it? If you are saturated with knowledge of all these things yourselves, you will bring them into your classes in spite of yourself, because your students from time to time ask leading questions, some of which you can legitimately use class time to answer.

In the second place, the members of this organization are the leaders in the secondary mathematical field. You are the people who make the innovations which are not forced upon you from outside. You can guide the course of mathematics teaching, or calmly wait until you are forced to change your methods by outside pressure. Many of you in this group are the textbook writers. The younger ones will be the textbook writers of the future. When you find that you are meeting the needs of your students and of the world, you can write more worth while textbooks. Many of you who work in the schools where someone does textbook writing have opportunities to

test the new books before they are put into final form. There is no reason why the next few years shouldn't see a real modernization in our mathematics. The plea to "socialize" everything can be used as an entering wedge. Those of you are in large systems could very well offer a new mathematics course called "socialized mathematics." If this is to be made attractive to the students of low mental intelligence, it can include a good deal of work on units and measurements, so called "laboratory" work with volumes and velocities, in fact, elementary algebra, a little plane and solid geometry, and some simple physics, trigonometry, and a little descriptive astronomy and the manipulative processes they will need in physics and chemistry and in the mechanical type of job so many of them will get into after they leave school. If it is to be a course for intelligent seniors, to follow elementary algebra and geometry, there is not much limit to what you can choose. Certainly some projective and non-Euclidean geometry, certainly probability, investments, logarithms, and slide rule, the nature of the number system, enough about complex numbers and determinants and matrices so that they can have some idea about the current theories of cosmology, space-time, indeterminism, and so forth. Teach them honestly and rigorously the little calculus that they need. Encourage and improve the books that offer calculus in the twelfth year course.

Does that program sound any worse than a program of calculus and theory of equations for his mature son would have sounded to the German merchant four centuries ago? I think not. Only, these things have got to be dug out and polished up and put in palatable form, which I admit they certainly are not at present. People are interested, adults will hunt eagerly and toil through dull pages but it is unreasonable to expect our adolescents to do so. In the Lincoln Public Library ten out of twelve of the semi-popular books on mathematics are out most of the time, Schroedinger's has been out every time I have looked for it for over a year.

I firmly believe, as many of you do, what as the psychologists are rediscovering, that pure mathematics, rigorously presented, gives a type of training that is "training for life" such as no other subject in the curriculum does or can. I also believe, that in the present state of mathematical knowledge, the classical courses in algebra, geometry, solid geometry, more algebra, and trigonometry, ought not to be held sacred.

I have tried not to suggest anything so revolutionary that any one of you could not adopt two or three of my suggestions next week or next semester. I think I have made enough suggestions so that the next time anybody mentions dropping or curtailing mathematics, you say, "Fine, just how much shall we discard, because here is a whole lot of stuff we think would be so much better to replace it." The result I hope will be such that when a bacteriology professor says to plot the growth curve on a logarithmic scale, his students will not look at him in wide-eyed amazement. Our physics classes can mean something because the students will not be so hopeless at applying and understanding formulas. Our teacher's college students will be able to read the new books on psychology which are so rapidly being written in purely mathematical language. I am referring to Thurstone's book on personality which has an introduction on matrices, and to quite an assortment of periodicals on education and psychology. The man in the street will have an intuitive idea of space-time cosmology. The biology students will recognize that Mendel's law is nothing but an application of the laws of chance, and the numbers of different types of offspring are the well known binomial coefficients. The man who buys an insurance policy or buys an automobile on time payments can figure out for himself just exactly what return he is getting on his money instead of taking the company's figures which look so pretty on paper. Clergymen will not have such naïve ideas about infinity, temporal or spacial. If I knew a little more about economics I could give you dozens of examples of pertinent applications of mathematics not too hard to teach in the high school, but you can find them yourself in the yearbooks of the National Council on Teaching of Mathematics. In fact, I see that there is a paper on the schedule tomorrow morning on that very topic.

I shall not say any more. I should like to say everything I have said all over again. We teachers get the impression that any point we want to get over has to be repeated ad nauseam, and we know that only a certain number of ideas can be absorbed in a given length of time.

I conclude with these four remarks:

1. Let us keep ourselves steeped, as far as in us lies, in what really goes on in mathematics.
2. Let us boldly fall in with the people who want to discard parts of the mathematics curriculum whose value is over-

emphasized, purely historical, or in any case dubious.

3. Let us not fear to make innovations whose social value is obvious. I cannot see that that is a disgraceful surrender of conservative mathematics.
4. Let the new text books be written with the teacher in mind. How can we who have been out of school five or ten or twenty, or thirty years, be expected to teach mathematics we have never heard of? The physics teachers have to teach physics they have never heard of. Text books containing innovations must be made fool proof as well as rigorous, entertaining, and practical. It is the only way in which progress can be made, for we must not lose sight of the fact that complaints come from the teaching done by the average teacher, not the work done by the type of person who is represented in a group like this, which is after all, a selection of the best.

Bibliography

Abbott, A., *Flatland, A Romance of Many Dimensions by A Square.* Little Brown, Boston, 1927. $1.50.

Ball, W. W. R., *Mathematical Excursions and Essays.* Macmillan. 10th ed. 1922. $3.50.

Bell, E. T., *Debunking Science.*

———, *Numerology.*

———, *Queen of the Sciences.* Williams & Wilkins Co., Baltimore. $1.00.

Buchanan, S. M., *Poetry and Mathematics,* John Day, 1929.

Collins, A. E., *Fun with Figures,* Appleton, New York, 1928.

Conant, *The Number Concept,* New York, Macmillan, 1933. $2.40.

Court, N. A., *Art and Mathematics,* Scripta Mathematica, Amsterdam Ave. and 186th St., New York. $.20.

Dantzig, Tobias, *Number, the Language of Science,* Macmillan, 1933. $2.50.

De Morgan, A. A., *A Budget of Paradoxes,* London, 1872 ($5.00 from Stechert).

Dodgson, C. L. (Lewis Carroll), *Pillow Problems,* Macmillan, 1895.

Dresden, Arnold, *An Invitation to Mathematics,* Holt, 1936. $2.80.

Euclid, Everyman Series. $.80.

Hicks, H. E., *Recreations in Mathematics,* Van Nostrand, 1917.

Hutton, Charles, *Recreations in Mathematics and Natural Philosophy,* 1803.

Jones, S. J., *Mathematical Nuts,* 1936. $3.50.

———, *Mathematical Wrinkles,* 1930. $3.00. S. J. Jones, 1104 Caldwell Ave., Nashville, Tenn. (both for $6.00).

Keyser, *Poetry of Mathematics and Other Essays,* Scripta Mathematica, New York. $.75.

Klein, Felix, *Elementary Mathematics from an Advanced Standpoint,* tr. by Hedrick and Noble, Macmillan, 1932. $3.00.

———, *Famous Problems of Elementary Geometry,* tr. by W. W. Beman and D. E. Smith, New York, 1910.

LA GRANGE, *Lectures on Elementary Mathematics*, Open Court, 1898 or 1901.
LIEBER, H. G. and L. R., *Non-Euclidean Geometry*.
———, *Galois and the Theory of Groups*. (258 Clinton Avenue, Brooklyn, N. Y. $1.00 ea., with 20% discount to teachers.)
LARRETT, R., *The Story of Mathematics*, E. Benn, Ltd., London, 1926.
LOGSDON, M. I., *A Mathematician Explains*, U. of Chicago Press, 1936. Text Ed. $1.75.
MACMAHON, P. A., *New Mathematical Pastimes*, Macmillan, 1936. $2.50.
MERRILL, H. A., *Mathematical Excursions*, Norwood Press, Norwood, Mass., 1933.
MILLER, G. A., *Historical Introduction to Mathematical Literature*, Macmillan, 1916.
MORITZ, ROBERT E., *Memorabilia Mathematica* (or the Philomath's Quotation Book.) New York, 1914, Macmillan. $4.00.
POINCARE, HENRI, *The Foundations of Science*, Science Press, 1921.
Rhind Mathematical Papyrus, The, ed. by Arnold B. Chace, Chicago, 1927, 1929, Open Court. $25.00.
SANFORD, VERA, *A Short History of Mathematics*, Houghton Mifflin, 1930.
SCHROEDINGER, EDWIN, *Science and the Human Temperament*, Norton, 1935.
SCHUBERT, H., *Mathematical Essays and Recreations*, 3rd ed. tr. by T. J. McCormack, Chicago, 1910.
SMITH, DAVID EUGENE, *A Source Book in Mathematics*, McGraw-Hill, 1929.
———, *Mathematics*, Marshall Jones & Co., Boston, 1923. (Our Debt to Greece and Rome Series.)
TURNBULL, W. H., *The Great Mathematicians*, Methuen and Co., Ltd., London, 1929.
WHITE, *A Scrapbook of Elementary Mathematics*, Open Court, 1908.
WHITEHEAD, A. N., *An Introduction to Mathematics*, 1911.

MEDAL OF ELECTRICAL ENGINEERS

Dr. Frank Conrad, prolific inventor and electrical engineer, will receive the prized Lamme Medal of the American Institute of Electrical Engineers. Presentation will be made at the summer convention of the society to be held in Milwaukee, Wis., next June 21 to 25.

Since 1890 Dr. Conrad has been associated with the Westinghouse Electric and Manufacturing Company, starting as mere bench hand and rising to his present post of assistant chief engineer.

Through the years he has made significant contributions to the field of applied electricity. Among his research developments are improvements in arc lamps, automobile ignition systems, mercury vapor rectifiers, radio telephony, telegraphy, electric clocks, measuring instruments for both alternating and direct current. He holds more than 200 patents.

Dr. Conrad has previously received other honors: the Morris Liebmann prize for 1925 of the Institute of Radio Engineers, the Edison medal of the American Institute of Electrical Engineers for 1930 and the John Scott medal of the City of Philadelphia in 1933.

QUARTZ—THE MAGIC MINERAL

By Glen W. Warner
Wilson Junior College, Chicago, Illinois

The most common and abundant things about us are often the least known and may be most interesting. The substance that fixes the frequencies of our broadcasting stations, analyzes sugars, furnishes some of our more precious and costly gems, resists the heat of the blow-torch and the dissolving power of strong acids, supplies the crystal gazer with his sphere of mystery, carpets our bathing beaches with a soft clean surface, enables the spectroscopist to investigate invisible light, provides one of the main constituents of the building material for great bridges, broad highways, and fireproof skyscrapers, and gives to suffering humanity the healing ultraviolet ray—that substance is at hand wherever we go. Oxygen is the most abundant element in the earth's crust, making up 46.46% of the whole. Silicon comes second with 27.61%. The two make up almost three-fourths of the entire outer shell of the solid earth. The combination of these two, quartz or silica (SiO_2), forms 59.14% of the igneous rocks. The sands of dune and desert and the great mountains of sandstone are almost pure silica. In fact it is almost impossible to take a short walk any place in the world without seeing some quartz.

Quartz is really the free acid which crystallizes when the magma contains a surplus of silica, more than is needed to combine with CaO and other bases to form compounds such as $CaOSiO_2$. The word quartz comes from the German but the clear crystalline form was known by the Greeks, who found some of the clear crystals and thought they were formed from water frozen so hard in the intense cold of the high Alps that they could not melt, hence called them crystals (clear ice).

In order to get a lucid picture of a quartz crystal it is helpful to consider first the most regular forms and then add the modifications. Such regular or typical crystals of quartz are rare but have been found in clay or limestone unattached to other rock. Such crystals are doubly or fully terminated, and consist of a hexagonal prism capped at each end by a hexagonal pyramid as shown in Fig. 1. The prism may be nearly or entirely absent.

Usually the crystals are found attached to the parent rock or mineral. These are singly terminated and consist of the prism and one pyramid, or of the pyramid only. A casual view of such

crystals leads to the conclusion that quartz has hexagonal symmetry. A more careful inspection, however, reveals that the faces of the prism or of the pyramids are not alike. The prism faces are usually crossed by a great system of lines all parallel to the edge of intersection between prism face and pyramid face. It will be noticed also that in general the three alternate prism faces are broader than the other three and that the broad faces are rougher, the lines more definite, than on the narrow faces. Also three alternate faces of the pyramids are larger than the other three. These large pyramid faces are usually designated by the letter *R*, the smaller ones by *Z*. If an *R* face of one pyramid bounds a face *m* of the prism at one end, at the

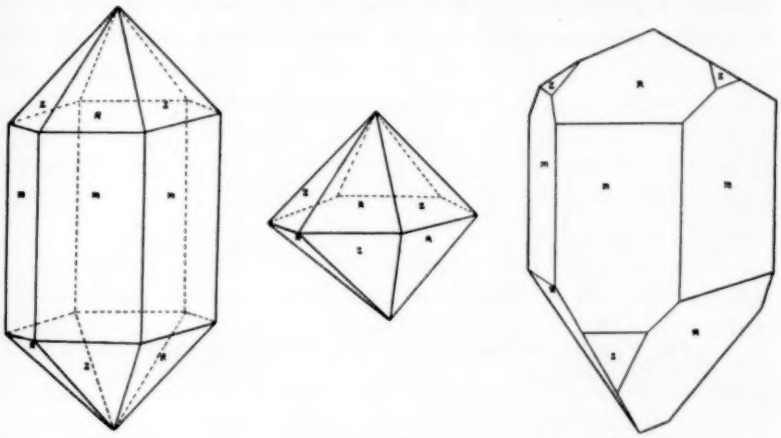

FIG. 1A FIG. 1B FIG. 1C

FIG. 1A. A perfect hexagonal crystal. FIG. 1B. Hexagonal crystal with prism absent. FIG. 1C. A common hexagonal form.

opposite end a pyramid face *Z* will be adjacent to *m*. Small triangles can frequently be found on the *R* faces. These features indicate that the symmetry of quartz is trigonal and not hexagonal.

A more careful examination of the typical crystal will reveal further and conclusive evidence of the trigonal symmetry. Figures 2 and 3 show small faces indicated by *s* and *x* in addition to the *m*, *R*, and *Z* faces mentioned above. The two crystals represented by these figures are seen to be mirror images of each other. In Fig. 2 the *s* and *x* faces are at the left of the *R* face; in Fig. 3, at the right. One or both of these small faces may be absent, or they may occur at only one place on the crystal instead of at three, or six if the crystal is doubly terminated.

If only one of these faces is present it is the *s* face. Frequently it is difficult to distinguish between the *R* and *Z* faces. Then the location of the small face will not assist in identifying the crystal as belonging to the form of Fig. 2 or of Fig. 3. Usually fine striations may be feund on the *s* face running parallel to the intersection with the *R* face. If these striations are present they identify the type.

The above characteristics show that quartz has three axes of symmetry intersecting at 120° to each other and terminated by the faces of the prism. These are the lateral or hemihedral axes. A fourth axis, the principal axis, is at right angles to the other three. The direction of the principal axis may be located by passing a plane through the prism parallel to the striations on the sides. The principal axis is normal to such planes. This is

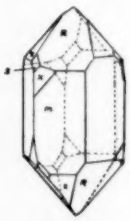

FIG. 2. A left-handed quartz crystal.

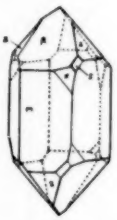

FIG. 3. A right-handed quartz crystal.

also the optic axis, i.e., the direction along which light will pass with uniform velocity whatever may be the direction of vibration in the wave front. The parallel striations across the prism faces are a characteristic feature of quartz and help to distinguish quartz crystals from other similarly shaped crystals.

In general the quartz crystals found in nature have no such regularity as those described above. Much of the quartz used for optical and other scientific purposes and for ornaments comes from Brazil. New York, North Carolina, Arkansas, France, Switzerland, Japan, and Madagascar have valuable deposits. The crystals range in size from minute specks to marvelous specimens a yard in diameter and length, and weighing half a ton. Most of these crystals are singly terminated and are attached to the rocky matrix from which they originated. Many peculiar and interesting forms are found. The two forms shown in Figs. 2 and 3 may be combined in many ways

forming *twins* which bring untold woes to the manufacturers of optical pieces and piezoelectric oscillators. Many twinned specimens have been found in Japan. *Cap quartz* contains mica or hematite scales arranged in regular manner making it possible to separate the crystals into layers. *Scepter quartz* consisting of a short thick crystal attached to a long slender prism, *skeletal or ghost quartz* with one crystal inside another, crystals containing bubbles, and crystals containing small crystals of other minerals form interesting variations.

Quartz has a number of properties which give it extensive use in optics. Its index of refraction is about that of optical glass but it is transparent to wavelengths far out in the ultraviolet. This makes it indispensable for prisms and lenses used in the study of the ultraviolet region of the spectrum. In 1811 Arago discovered that when plane polarized light is transmitted through a thin plate of quartz in the direction of the optic axis, the plane of polarization is rotated. The direction of rotation depending upon the crystal form. A plate cut from a crystal of the form of Fig. 2 rotates the plane to the left or counter-clockwise, hence these crystals are called left-handed; those like Fig. 3 are right-handed. The degree of rotation depends upon the thickness of the plate and the wavelength of the light. For a wavelength of 5895 A the rotation produced by a quartz plate one millimeter thick is 21.7°. For $\lambda = 4307$ A the rotation is 42.6°. The amount of rotation is the same for both right- and left-handed quartz, hence the rotation can be nullified by passing the light successively through right- and left-handed plates of equal thickness. This gyratory property is employed in the "half-shade" plate of the Laurent saccharimeter. It should be compensated for in lenses used on apparatus for experiments in polarized ultraviolet light. This can be accomplished by making the lenses in two parts—a plano-canvex lens of right-handed quartz combined with a similar plano-convex lens of left-handed quartz If this is not done the various lines of the spectrum will hav their planes of polarization widely distributed due to the great amount of rotation in the short wavelength region. A few other crystals having the ability to rotate the plane of polarization are known, the most important of which is cinnibar which has much greater ability to rotate than quartz.

One of the distinguishing characteristics of quartz is its hardness. It cannot be scratched by steel, but yields to a few natural substances such as diamond, corundum, and topaz and to such

artificial abrasives as carborundum and aloxite. It was chosen as No. 7 in Mohs' scale of hardness. This makes the cutting, grinding, and polishing of quartz a tedious process, but after the articles are made they are not readily scratched. Quartz is, however, quite brittle and breaks with a conchoidal fracture. Its specific gravity is 2.66.

Quartz is a non-conductor of electricity but a good conductor of heat. This latter property makes it feel cold to the touch, which provides a rough method of distinguishing between quartz and glass objects. It is not attacked by acids except hydrofluoric, but it is slightly dissolved in strong alkali solutions. The high melting point of quartz, nearly 1500°C., makes it suitable for chemical ware where high temperatures are required and for tubes for high temperature thermometers. Hot fused quartz is exceedingly ductile—it is possible to draw out fibers so fine that a single pound will reach entirely around

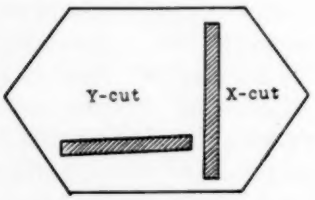

FIG. 4. Diagram showing how to make x-cut and y-cut oscillators. The optic axis is perpendicular to the paper.

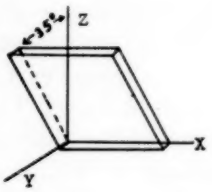

FIG. 5. Diagram showing the method of making an AT-cut oscillator.

the earth at the equator. The very fine threads are used for suspensions for mirrors and other light indicators in delicate scientific apparatus. The specific gravity after fusion is 2.2 and hardness 5.

In 1880 J. and P. Curie discovered a new property of quartz. They formed rods or plates from quartz crystals by first cutting sections parallel to the striations on the crystal faces, i.e., perpendicular to the principal axis, and then cutting perpendicular to one of the prism faces as shown in Fig. 4. When such plates were compressed or elongated in the direction of the lateral axes, along the y direction, charges of opposite sign were produced on the faces perpendicular to the x direction. The following year the converse effect, that of producing distortion in the

y direction when an electric field is set up in the *x* direction, was predicted by Lippmann and experimentally verified by the Curies. The electric effect due to a mechanical distortion is spoken of as the direct effect; the mechanical strain due to an electric field is called the converse effect. Both are known as piezoelectric phenomena. A bar or plate cut as above described is called a curie-, x-, or perpendicular-cut. The x-axis is also called the electric axis. When an alternating electric field is impressed in the *x* direction the crystal is set into vibration, increasing in length in the *y* direction and decreasing in the *x* direction with one alternation and *vice versa* in the other half of the cycle.

Nothing more of importance was done in this field until 1918 when Langevin made use of the oscillations of quartz bars cut as described above to set up ultrasonic waves and transmit them in water. Such devices are now used in depth sounding. In 1922 Cady made use of piezoelectric crystals for stabilization of frequencies in radio circuits. Since that time many investigations have been made in this field and numerous applications of piezoelectric oscillators have been developed. One of the important uses is in the construction of microphones for public address and other systems where reproduction and amplification of speech and music are required. Rochelle salt crystals are also widely used for this purpose. Cady and others working in the radio field found that quartz crystals cut at an angle of 30° to the electric axis, i.e., parallel to a prism face, were more easily set into oscillation than those x-cut, hence they are extensively used by radio amateurs, and are called parallel-, y-, or 30°-cut crystals. These plates are not as reliable as the x-cut ones because temperature changes produce greater variations in frequency. The range is from an increase of 100 cycles to a decrease of 20 cycles per million per degree centigrade, as compared to a range of a decrease of 20 to 35 cycles per million per degree for the curie-cut crystals. The high fidelity of the latter type has established their use in all radio broadcasting stations for stabilizing frequencies. Recently there has been developed in the Bell laboratories a method of cutting which results in almost perfect performance. This type is shown in Fig. 5 and is called an AT-cut. It results in reducing both coupling (which is the cause of much of the misbehavior of the y-cut oscillators) and the temperature coefficient to zero. Studies in this field show that such crystals as quartz possess not only the usual

elastic constants which vary with the crystal axes as in a piece of wood, but in addition a set of piezoelectric constants which also vary with the axes, thus producing a very complicated condition. The variation of Young's modulus for quartz is so great that it includes the value of this constant for aluminum, copper, brass, silver and gold. Though the difficulties are extremely great, rapid progress has been made, yet research in this field and applications of the piezoelectric properties of crystals in science and industry seem to be only well started. Wood and Loomis have carried out a series of experiments with quartz oscillators to develop ultrasonic waves of great intensity which show that such waves may be used to produce some startling physical and biological effects. Their experiments indicate that such waves may some time become very important in physical therapy.

In addition to the extensive use of pure quartz crystals in industry and communication, there are many modifications which supply beautiful gems and valuable products for commercial use. The original rhinestones were cut from clear quartz crystals. Amethyst is violet or purple colored rock crystal. On heating, the color changes to a golden brown and the gems are offered to the public as "topaz." False topaz, Spanish topaz, and citrine are names given to quartz light yellow in color. True topaz is fluosilicate of aluminum, $Al_2(F\ OH)_2SiO_4$, and has a hardness of 8. Smoky quartz, also called smoky topaz and cairngorm, is smoky yellow to dark brown in color. Switzerland, Scotland, Maine, and Colorado have furnished magnificent crystals. Rose quartz is a beautiful pink to rose red in color but fades on exposure to light. The color is partially restored by keeping it for a considerable time in a dark, damp place. It is seldom found in distinct crystals but occurs massive in large veins as at Bedford, N. Y., and Custer, S. Dak. Milky quartz is translucent or opaque. Beautiful crystals are sometimes found but it is usually massive. Aventurine contains scales of mica or hematite arranged in parallel. Rutilated quartz contains fine interlacing needles of rutile. Cat's-eye quartz is due to the inclusion of parallel fibers of asbestos.

Chalcedony is generally considered a form of quartz or a mixture of quartz and opal. Its refractive indices, specific gravity and hardness are all slightly less than quartz but the x-ray powder photographs are alike. Red colored chalcedony is called carnelian or sard; apple green is chrysoprase; green containing

small spots of red jasper is heliotrope or bloodstone. Agate is striated or banded chalcedony formed by deposition in stages. The bands may vary in width from about a quarter of an inch to so small that they cannot be distinguished without the aid of a microscope. Sir David Brewster counted 17,050 lines to a single inch in one specimen. Some agate, however, is not banded but is mottled, or contains fantastic shapes forming the moss agates and tree agates. Onyx is parallel banded agate. Most of the agate used commercially is artificially colored by dyes absorbed in the porous parts. The black color is made by first soaking the specimen in a sugar solution and then charring the absorbed sugar by dipping into a solution of sulphuric acid.

Jasper, flint and chert are other forms of opaque quartz. Jasper occurs in a number of colors and is used for table tops and other ornamental objects. It is widely distributed but Siberia and South Africa have the greatest quantities.

The most common deposits of quartz are the loose grains that form the sands of sea and lake shores and desert, and are an important constituent of the soil everywhere. When the loose grains are cemented with iron oxide, calcium carbonate, clay, or silica, sandstone is formed. When silica is the cement and the rock has been metamorphosed by heat and pressure, the result is quartzite, one of the most valuable stones for building and paving. Twelve million dollars worth of sandstone and quartzite is sold annually in the United States. Next to water quartz is the most abundant oxide. It furnishes the bulk of the material for the manufacture of glass, mortar and plaster for construction; it supplies the effective material for sandpaper and other abrasives. Ground or powdered quartz is used in wood fillers, pottery, scouring powder, soap, and as a flux in numerous metallurgical processes. In scientific work it performs a multitude of duties that no other known substance can do.

Here then is a substance of great utility, abundant and conveniently distributed, inexpensive but enduring. It is, moreover, a substance of wondrous beauty and endless variety, in many of its forms rare and costly; a substance with such intriguing properties that it claims the attention of savants, sometimes confounding their investigation but often bringing success, and promising to reveal more of nature's well-guarded secrets.

References

Bragg, Sir Wm. and Gibbs, R. E., "The Structure of α and β Quartz," *Proc. Roy. Soc.*, p. 405, Vol. 109, No. 751, 1925.

CADY, W. G., "Piezo-Electric Standards of High Frequency," *Jr. Opt. Soc. Am.*, p. 475, Vol. 10, April 1925.
DYE, D. W., "The Piezo-Electric Quartz Resonator and Its Equivalent Electrical Circuit," *Proc. Phys. Soc.*, p. 399, Vol. 38, 1925–26.
EDSER, EDWIN, *Light for Students*, Macmillan and Company, London, 1911.
ENGLISH, GEORGE LETCHWORTH, *Getting Acquainted with Minerals*, McGraw-Hill Book Co., New York, 1934.
GIBBS, R. E. and THATTE, V. N., "The Temperature Variation of the Frequency of Piezo-Electric Oscillations of Quartz," *Phil. Mag.*, p. 682, Vol. 14, October, 1932.
HAWKINS, ALFRED C., *The Book of Minerals*, John Wiley and Sons, New York, 1935.
HUBBARD, J. C., "A Brief Survey of Supersonics," *Jr. Acous. Soc. Am.*, p. 99, Vol. IV, No. 2, October, 1932.
KRAUS, EDWARD HENRY and HUNT, WALTER FRED, *Mineralogy An Introduction to the Study of Minerals and Crystals*, McGraw-Hill Book Co., New York, 1928.
LACK, F. R., "Observations on Modes of Vibration and Temperature Coefficients of Quartz Crystal Plates," *Bell Sys. Tech. Jr.*, p. 515, Vol. VIII, No. 3, July, 1929.
SPENCER, L. J., Article on Quartz, *Enc. Brit. 14th Edition*, p. 830, Vol. 18.
VIGOUREUX, PAUL, *Quartz Resonators and Oscillators*, H. M. Stationery Office, London, 1931.
WILLARD, G. W., "Elastic Vibrations of Quartz." *Bell Lab. Rec.*, p. 250, Vol. 814, No. 8, April 1936.
WOOD, ROBERT W., *Physical Optics 3rd Edition*, The Macmillan Co., New York, 1934.
WOOD, R. W. and LOOMIS, ALFRED L., "The Physical and Biological Effects of High Frequency Sound Waves of Great Intensity," *Phil. Mag.*, p. 436, Series 7, Vol. 4, September 1927.
WOOSTER, W. A., Article on Chalcedony, *Enc. Brit. 14th Edition*, p. 193, Vol. 5.
———, Article on Jasper, *Enc. Brit. 14th Edition*, p. 970, Vol. 12.

THE EDUCATION OF TEACHERS OF SCIENCE

The Ninth Conference on the Education of Teachers of Science was held at New Jersey State Teachers College, Montclair, N. J., Nov. 6 and 7, 1936. The program included the following:

Mr. Merwin M. Peake: Science Education in the Junior High Schools of New Jersey.

Mr. Gordon Taylor: What Materials of Instruction Should Be Provided for Science Pupils in the Junior High Schools of New Jersey.

Dr. V. T. Thayer: The Work of the Commission on the Secondary School Curriculum.

Dr. Ellis Haworth: Report of Committee on Minimum Essentials for Certification of Teachers of Science in Junior and Senior High Schools.

Dr. E. G. Conklin: The Part To Be Played by Science in Future Education: Some Observations and Recommendations.

Dr. Martin L. Robertson, Mrs. Anna M. Gemmill, Dr. W. L. Eikenberry, Mr. R. E. Bowers: The Place of the School of Practice in the Education of Teachers in Science.

BIOLOGY IN THE SOUTHLAND*

By Peter Blos

Metairic Park Country Day School,
New Orleans, Louisiana

I want to restrict myself in this paper to a limited area in the South, to Louisiana. I am now in my third year in this state and have become somewhat familiar with its wild life, and know more how to adapt biology to these natural advantages than I do in any other state.

This part of the South where I live is certainly favored for biology studies; the near Gulf Coast, the inland lakes, the fresh and brackish water basins, the bayous, the marshes, the swamps are habitats of very great ecological interest and rich sources for biological material. The short winters favor outdoor study. The swamp vegetation shows instructive adaptations, as illustrated by the cypress tree, a gymnosperm with leaf-like needles and with branches, resembling small fern fronds; besides the leaves, which with their enlarged surfaces, care for rapid evaporation, we find in the so-called cypress knees another adaptation to life in water; the cypress knees, extensions from the roots through the water into the atmosphere, provide the necessary oxygen to the under-water parts of the root-system. In the shadow of these trees, which disclose by the typical monopodial ramification their relation to northern spruce trees, just as animals of the same family, with divergent adaptations, bear in their skeletons hidden proofs of relationship—in the shadow of these magnificant giants of the swamps are floating rafts of thousands of water-hyacinths which a lover of flowers had carelessly imported from South America. This water-plant has spread with such rapidity that the fishing boats in the bayous have sometimes to struggle through the purple carpet as ships in olden times had to fight their course in the Atlantic through the weeds of the Sargasso Sea.

The bird life is rich in winter and summer, changing the regular bird calendar which southern children learn from books written in the North and which asserts that birds leave us in the fall and travel South and return in the spring. Actually they arrive from the North in the fall and many stay, and in the spring they start their trip to their northern homes. In the fall

* Read before the Biology Section, Central Association of Science and Mathematics Teachers, St. Louis, November 27, 1936.

we see large flocks of migrating birds going down to the ground in order to satisfy their appetites on hackberries, dogwood, or insects; it seems as if they seek a last rest before taking up the crossing of the Gulf.

The evergreen trees are mainly represented by the magnolia and the live-oak. The latter is usually hung with Spanish moss (Tillandsia usnoides, L.), a member of the pineapple family and an epiphyte of high specialization. It contains chlorophyll, even if it looks grey, and it provides enough water for its life-processes out of the air, which has a high degree of humidity. Moving towards the North, we notice this lichen-like drapery disappear as soon as the average humidity drops below a certain level.

Animals which deserve special mention with reference to high school biology are the Amphiuma and the Opossum; both of them have been caught several times by my students and kept for awhile at school for observation and discussion. Nor may I omit the alligator and the bullfrog, this giant and convenient victim for dissection.

In this naturally rich setting it seems that biology may be easily made into a colorful and varied course.

Let us stop here and consider for a moment the students who fill our biology classes. They are certainly not biologists and therefore not primarily satisfied by the naturally rich setting. Our biology students enter our course with the greatest variety of interests, and we have to consider these facts if we do not want to risk wasting our effort. The method as well as program of our biology course has to be determined by the psychological characteristics of the learner to be as effective as possible. I have more to say about this point, but before entering the discussion I want to settle the question about early formation of interest in biology.

I have already pointed out in my previous paper[1] with enough analytical and experimental proofs, that the appreciation of natural facts and the interest in biological studies have to be built up early. I will therefore be very brief here. We can certainly not expect, if we are teaching biology in high school, that all former biological experiences of our students will have no bearing on their present attitude towards the subject in general, their attitude concerning serenity, maturity, open-mindedness, interest and originality. Do you think that these

[1] SCHOOL SCIENCE AND MATHEMATICS, Jan. 1937, p. 30.

attitudes are just the result of chance? Probably not. They are conditioned just as well as other traits and skills. We should give this conditioning process a little more thought.

I do not want to repeat myself here. Therefore, briefly summarizing the conclusion at which I arrived in my other paper, I may say that I consider the elementary school the place for building up appreciation and interest in biology. Some knowledge about basic physiology (demonstrated by representative experiments), dissection of organs like heart and eye, use of microscope in plant and insect studies, acquaintance with a variety of animals with reference to their natural habitat, their characteristics, and life-history—all this information should be collected during early years. Children at that age are not only keen about it, but are the most clever animal- and plant-keepers I know. Having living material around the school from the first grade on, children develop a marvelous ability in handling living material and in observing it. Our children regularly keep animals like fish, frogs, amphiuma, snakes, turtles, alligators, opossums, birds, ducks, chickens, silkworms, etc. An astonishing amount of factual knowledge can be accumulated during these elementary years, which gives us the important time of biology lessons at high school level free for more age-adequate teaching and studying. But—you may interrupt me—our course is more or less bound by college entrance requirements. What is the use of good ideas, whatever they may be, if you are bound by those standards? The number of the board examinees is shrinking every year, and you know of the trend towards removing those strait jackets from high school education. We have to think beforehand of what we are going to do with the new freedom when it may have arrived.

First of all: in order to have a successful program we have to have an interesting one. We can build it up only if we keep in mind the trinity: the student, the learning process, and the program. The psychological characteristics of the learner determine the time or the age when each unit of information as a part of our cultural heritage should be offered to the growing mind for assimilation, or—in plain language—should be taught. Considerations of the kind mentioned here lead to an age-adequate program, based on physiology and psychology. We cannot consider the growing human to be in its different stages of development or age a primitive, immature adult. Each age-level has its limitations and powers and they have to be considered if we

want to make use of natural conditions, physically and mentally, towards *age-adequate living and thinking and learning.* This is the aim of any subject-matter.

To make my point clearer I will turn to a discussion of the age-level which fills our biology classes. The age-level is adolescence. The developmental progress from pre-adolescence to adolescence in terms of psychology is the consolidation of the self-controlling system, the ego, and the loosening process of the close ties to the family. The adolescent exchanges the family for a congenial group or society in general. In search for life-patterns, ideals, or identifications he turns his interests beyond the family, usually finding them in the realm of personal acquaintance with history, science, politics, sports or movies. For the first time the adolescent is deeply concerned with the question of where his place is in society and whether he is wanted, liked, and accepted. The horizon of the intellect is broadened and extremely open to problems of general concern, especially social, biological, psychological, and cultural. The adolescent is primarily concerned with questions of his own development, physically and mentally, with questions of sex and sex-relations, family, society, religion, vocation. There are mainly two subject-matter fields which can take the lead in clarifying those problems: biology and social science.

So far as biology courses of study are concerned, they are not at all adjusted to this need but are still simplified knowledge, adult information talking down to a lower level. This attitude is exactly what the adolescent resents in life, but accepts it stoically at school.

Take a look at our biology text books. I know they are dictated by college requirements. They are nothing else than simplified college text books; a vain attempt for completeness; somewhat logically arranged encyclopedic information; descriptive data, most of which is essential for a biology student at college, but has little or no educational value at high school level. A little bit of everything, impossible to present it in one year's course without being engorged by the Scylla of superficiality or the Charybdis of drillwork. We can not get around the basic truth that we have to adjust method and program to the psychological characteristics of each age-level. Instead of thinking in terms of content, we have to think rather in terms of general outcomes.

What does the adolescent expect from biology? Overshadow-

ing the fascination of everything else in biology is the interest in man, the unknown. That is the reason why I spend in the beginning of each course about four to five months in studying man.

In the following I want to express some leading ideas of this study. Besides anatomical features, the knowledge of which is indispensable, I attempt to bring forth an understanding for the complexity of life processes, for the equilibrium maintained by the body, for the cooperation and coordination of its organs. Walter B. Cannon suggested naming this system or tendency to maintain constant and stable conditions in the body, *homeostasis*.[2] This important conception of the American Pavlov is worth while considering even for high school studies.

To illustrate homeostasis on one bodily activity, I will choose the maintenance of an adequate oxygen supply. We can spare food for weeks and water for a day or longer but oxygen for only a very short time. Energy and water are stored in the body for emergency but oxygen is not, since it is abundant around us under normal conditions. Faster respiration and faster heart-beating during and after strenuous exercise are common observations. But what accounts for these regulating actions and how are they coordinated in the body?

During muscular action lactic acid is produced as an intermediate product of glucose oxidation. The lactic acid, if accumulating in the muscle, finally paralyzes it; therefore rest is required to oxidize the acid to water and carbon dioxide or to reconvert it into glycogen. To postpone this process until the body has come to rest and to avoid the paralyzing effect in the muscle, the lactic acid is "buffered" or neutralized as sodium lactate for the time being. Enough oxygen is taken in, after the exercise is over, to burn the accumulated waste. This we call after Hill the "oxygen debt" and the fast respiration which lasts after the exercise for a considerable time can be accounted for as paying the debt which we run up while being in action. It is obvious that oxygen in large quantities is necessary for the active muscle in order to liberate energy and to burn waste.

The deeper breathing is caused by increased carbon dioxide content in the blood, which stimulates the nerve center in the cerebral cortex. The carbon dioxide in the blood rises if the diffusion pressure of carbon dioxide in the pulmonary capillaries and in the alveoli is such that not enough of the carbon

[2] Walter B. Cannon, *The Wisdom of the Body*. 1932.

dioxide can escape from the blood into the alveolar air. A rise of .22 per cent of carbon dioxide increases the ventilation by 100 per cent. The ventilation stimulated originally to get rid of the dangerous carbon dioxide leads necessarily to the desirable supply of more oxygen. We notice at the same time that the circular muscles of the bronchioles relax; this reduces friction and guarantees a greater volume of gases entering and leaving the lung. The sympathico-adrenal system is responsible for this adaptation of the air passages and we understand in this connection the relief which is brought to a sufferer from bronchial asthma by a dose of adrenalin.

Before we even start to exercise, but merely think, for instance, of running, the liver sheds glucose into the bloodstream and the vasomotor nerves contract the vessels of the digestive canal. This contraction causes the arterial bloodpressure to rise, and therefore the blood is sent through those parts of skeletal muscles where it is needed with higher speed. The dilation of the arterioles and capillaries of the active muscle allows more blood to rush through its tissue. It is worth mentioning that in resting muscles many capillaries are not in use. About forty to one hundred times more vessels are in service while the muscle is active than while it is at rest. The contracting muscle itself supports actively the flow of the blood, because the rhythmical pressure on the vessels pushes the blood—especially in the veins, in which the backward flow is prevented by valves—towards the heart. The muscle itself acts like a pumping station while it is working! The contraction and expansion of the diaphragm promotes also the flow in the voluminous inferior vena cava. During inspiration the diaphragm flattens, presses upon the abdominal viscera, including the vena cava, and forces the blood upwards. The diminished pressure at the same time in the pleural cavity acts like a sucking force and promotes an accelerated flow.

As we have already stated, the heart adjusts itself in two ways. The rate is increased by suppression of the vagus impulse. But it cannot put out more blood than it receives. There we remember that through muscular action and respiration the flow of the venous blood is speeded up and venous blood pressure is therefore increased. This leads to a greater dilation of the right auricle during the diastolic stroke which excites the sympathetic nerve and speeds up the heart. Besides increasing the speed and volume of the blood flow, the spleen will in

emergency add new oxygen carriers or red corpuscles to the blood, thus taking its share in adjusting itself to the situation.

To complete the picture, I will briefly discuss the question how the cells of the active muscle are able to get the oxygen from the faster running blood. It is fascinating to find that heat hastens the unloading of oxygen from its carriers; heat production is, on the other hand, a direct result of action and oxidation. Since the oxygen is used up rapidly in active tissue, the diffusion gradient of oxygen from blood to lymph becomes steeper and four times more oxygen can be taken away from the red blood corpuscles than in ordinary inactive condition.

This brief sketch of homeostatic considerations in reference to one physiological process must be enough to illustrate the approach of which I talked in the beginning. An interwoven fascinating coordination of all organs is revealed in such an analysis, which is not too difficult to be understood basically by high school students. We could take any bodily function and finally arrive at a similar complex picture, which at least avoids the naïve comparison of the body with a mechanical device or a machine in general.

Organs have regulative and adaptive functions to protect the organism against endangering stimuli. These stimuli may come either from the environment which surrounds us (like heat or light) or from the internal environment or "milieu interieur"—to use an expression of Claude Bernard—like changes of sugar or calcium content in the blood. By contrasting the organism with the environment, I strike a keynote for our further discussion. Both—organism and environment—are inseparable and constitute a biological unit. Man and amoeba live only in reference to their environment, and even the highest qualities of human mind are the product of the social environment which man has experienced for ages. You already noticed that I refer to the viewpoint of ecology, which is the second leading idea which—I think—should penetrate our high school biology. T. W. Bews, who has recently published a book on "Human Ecology,"[3] has helped a great deal to systematize this highly interesting field of modern biology.

Man's response to his environment is certainly complex. The physical environment is one factor which has to be considered; his response to temperature, light, radiation, humidity, atmospheric pressure and climate as a whole leads to a much

[3] Oxford University Press, 1935. Introduction by General J. C. Smuts.

broader conception of a study of man. It is basic to understand the survival of species, e.g., that man survived while many of his Miocene contemporaries were extinguished, due to his great adaptability and his lacking specialization. His power to control his environment gives him his great supremacy among higher animals.

Part of our environment naturally is the human beings which share our life in one way or the other. They make our social environment, which can be described in terms of psychology. I recall the opening of a biology class in which I discussed with my students what they expected from the course. We came across the question: When do we realize that we are living? When are we actually concerned with life as conscious sensation? The students decided that we are aware of life processes in us only if we are happy or sad, if we love or hate, if we are angry or sorry. All these emotional sensations have to do with our social environment. Therefore I consider it essential to study some basic facts about our mental development and social adjustment. Genetic psychology, which comes in closest reach of physiology, can provide such a study with enough age-adequate material. The conditioning and reconditioning process of reflexes should be stressed as part of the study. The ingenious work of the great Russian physiologist, Pavlov, and his experiments on dogs strike every student with fascination.

I am sorry that I am getting almost too brief and sketchy. But I want to complete the picture, nevertheless, in the allotted space.

I pay special attention in my biology course to a study of sex and its biological significance, of ontogenesis, or, better, of embryonic life and of individual development from babyhood to adulthood. I consider a comparative study of prehistoric man important for better understanding of phylogenesis or evolution. This asks for a fair knowledge about anthropoid apes and throws a light into the workshop of anthropologists who devote their lives to clarifying the problem of human descent.

Besides original and professional literature which we consult, we seldom make use of a high school biology text book. The money spent for text books is much better invested if everybody contributes to the purchase of different books. It is certainly much more stimulating to have twenty different books on hand than twenty identical ones. This year I gave up the use of a text book entirely. The students decided to write their

own book while we are proceeding in our studies. These hand-written and hand-illustrated notes are followed up and kept with much neatness and care.

I can feel that you want to interrupt me and ask: But when do you bring into the course a study of plants and animals in general? It also holds true for those studies that nothing should be learned for its mere descriptive sake. The ecological point of view has to lead us again.

I recall a study on insects which started from a discussion about the economical importance of insects and about their social instincts. We soon noticed that we had to know the life history and the anatomy of an insect—at least of the mouth parts—to be capable of fighting it. To spray a tree when a sucking insect does the damage will be naturally ineffective. This led us to a comparative study of mouth parts of the five different types. Posters of mouth parts were drawn in which the homologous pieces were indicated with the same color, clearly showing that analogous use can be made of different parts. The value of this study lies—I think—in the general biological law which was the outcome of this work, besides very rich factual information. Experiments performed by Jean H. Fabre and Charles Darwin with bees were read and discussed. Metamorphosis provoked by the stimulus of the climatic conditions during the ice age, gave rise to talk about the problem of instinct and intellect. The importation of Tachina flies from Japan to fight the Japanese beetle or the destruction of the codling moth with the ichneumon wasp or the spraying of forests from airplanes in connection with studying pamphlets put out by the government, led to so much interesting information that we decided—as usually under similar circumstances—to give an assembly program for the whole school. I consider such assemblies very worth while, because I believe we can only talk interestingly about things which we know thoroughly. If the audience became bored, I always blamed the speaker, and discussion about that led to many constructive suggestions and established a sort of assembly technique and tradition. In similar ways many other studies about the greatest variety of subjects were carried out. Dissection of representatives of the different classes of vertebrates were undertaken once for the sake of a comparative study of the circulatory system. At the end we arrived at a genetic understanding of circulation from fish to mammalian embryo. Another time a study of heredity

led us close to social science and mathematics, and we got help from these departments. One boy copied Galton's chance apparatus in order to illustrate very convincingly the chance or binomial curve.

Time does not allow me to tell you more about this part of the study, but, summarizing the general idea, I may say that each working unit must be as intensive and extensive as possible, must be saturated with ecological and genetic considerations, and must end in the understanding of some general biological method or law.

At the end I must finally tell you what use we make of the advantages which nature in the South offers us. Each spring I take my biology class to the Gulf coast for a week to study marine life. The camping and the planning experiences are just as important as the biological study. The planning has to be done very carefully because Dauphin Island—where we stayed the last two times—is an hour's boatride away from the main land and has very restricted resources. We have to carry everything with us which we are going to use for the time on the island. The planning consists in mapping out a list of needed food, in budgeting, in assembling the scientific equipment for catching water and land animals, for preserving specimens, for doing microscopic work, for dissection, for collecting plants, for observing birds, for photographic records, and for drawing of different objects; not to forget the reference books for information and identification. Our last record showed about sixty items which had to be considered by the committee for science equipment. Nets to dredge and to collect plankton were made by ourselves. For observation under water we made an observation box on the principle of the glass-bottomed Bermuda boats, and for close observation of live material which we caught from the boat, we had an aquarium tank on board. It was fascinating to see in it the stingaree swimming and the squid disappearing in a cloud of sepia.

The variety of life-forms with which the students get acquainted in a very direct way is enormous. The plankton itself contains one-celled plants as well as animals and different larvae of metazoa. Sponges and coelenterates were studied intensively, especially the Portuguese Man-o'-War. Jellyfish, worms, and echinoderms were collected. The gastropods, the cephalopods, and crustaceans are abundant. And—as you can imagine—the number of fish we catch while trawling through the open Gulf

is very great. So far we have collected twenty-five varieties, which are preserved and kept in the biological museum at school. Even aquatic mammals—the porpoise—keep steadily around our boat, trying to catch the fish out of the trawl net; at the same time seagulls flutter around, screaming and fighting over the fish which we throw back into the water. The waves are rocking the boat while we are sorting our material. Pelican Island can be clearly seen through the field glass, with hundreds of pelicans, but the huge birds take off in cloudy flocks while we are slowly approaching.

Hikes on the island are always full of observation and collecting. Very early in the morning we go out for bird-walks. The influence of the wind direction on the distribution and adaptability of different plants and trees leads to ecological problems of plant formation. Carnivorous plants are collected. Insects in various stages are found and their life-history studied. Amphiuma, turtles, snakes complete the picture of the rich variety of living material with which the students get closely acquainted.

Besides observing, collecting, and preserving while on the island, we also dissect fresh material as much as possible and make drawings of it, further study plankton, identify, and keep exact records. This work is scheduled and interrupted by the most pleasant swims in the surf, by chopping firewood, by cooking and washing dishes. When it is getting dark and the night hawks are plunging through the air catching mosquitoes, we all go down to the beach and light a fire of driftwood, sit around it, and tell ghost stories, play games, or have serious talks.

Returning with the treasure of records and preserved material, the laboratory work actually begins. Some of the students specialize in plankton, some in insects, some in plants, some in fish, some in birds, some in shells, some in cephalopods, some in sponges, some in coelenterates, or some in ocean currents and the Sargasso Sea. Each study group has to complete a report, usually with illustrations, and these reports, along with the diary kept and the reports of the different organizing committees, is finally put together and made into book form. It would be very worth while if I had time to tell you some more about these studies and the way they are carried out. But I have to come to an end.

Summarizing, I may say: *A high school biology program has*

to be based on the psychological characteristics of adolescence. It has to be age-adequate. A great deal of factual knowledge should be collected earlier. At high school level the study of man should stand in the foreground; its study has to be intensified and penetrated by homeostatic, ecological, and genetic ideas, because in plain language—each organism needs constant conditions in its system in order to survive. Further, it is a part of the environment in which it lives, and last, it has become what it is at present by the process of development. No organism should be studied for its mere descriptive and anatomical sake. This does not preclude our not going deeply into anatomical studies. We certainly should if it is done with the purpose of arriving at important biological generalizations or laws.

High school biology is not simplified college biology. It should be an age-adequate study which is intentionally planned to foster individual development as well as scientific learning.

FROZEN ODORS

Few things in the physical world are more difficult to describe and more difficult to measure than are odors. It is therefore necessary for science to do the unusual in studying odors and the newest trick in the measurements of smells is to freeze them. Frozen odors, in fact, are among the techniques of the air conditioning engineers who maintain, and constantly seek to improve, the ventilating units on the Pullman cars of the nation's railroads.

V. A. Gant of the University of Illinois Medical School and H. D. Shaw, research scientist of the Pullman Company, have just reported to the American Chemical Society that the design of filters to remove the odors from a smoking lounge car or sleeping car is facilitated by the frozen odor feat.

The conditioned air of a lounge car, for example, consists of about one part fresh air and three parts recirculated air. All too soon it may become objectionably odorous.

"The condition of the atmosphere during and after a trip is best described by likening it to that of an improperly ventilated room where persons have been drinking, smoking and playing cards," the report points out.

In the test the air of the car was filtered through dry ice, or solid carbon dioxide. The frozen odors and moisture were placed in a wide-mouthed bottle into which an osmoscope was inserted. This instrument measures smells by determining the concentration of fresh air at the time the smell becomes apparent to the technician.

Once the odors were individually identified a carbon filter was devised which removed them without itself exuding any odor. Activated carbon, so widely used in the first World War gas masks, was found to work admirably. Life of the filters was found to be at least four months.—*Science Service.*

A FUNCTIONAL LESSON PLAN FOR SCIENCE TEACHING

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A paramount practical problem in the training of science teachers, is the development of a functional lesson plan, which includes all phases of the organization and administration of the unit.

A plan which has been developed by the writer and his student teachers may be presented as a plan which has been found to function very satisfactorily for the critic and student teacher.

ORGANIZATION OF THE UNIT

The plan is divided into two major divisions, namely, (1) the organization phase, and (2) the administration phase of the unit. The organization phase first includes the unit theme which identifies the unit as to its general content. This theme is given in the form of a statement which expresses an idea, as recommended by the Committee on Science Teaching of the National Society for the study of Education,[1] rather than in the conventional topical form. The second step in the organization is to enlarge upon the unit theme with a statement or statements giving the major concept which the pupils should acquire from the study of the unit.

Following the major concept, a statement of the objectives should follow. The hierarchy of objectives may be classified according to three levels, namely (1) aims, (2) general or ultimate objectives and (3) specific objectives. In order to train the student teacher to take the "long view" of the learning unit, i.e., to keep the ultimate objectives in mind while organizing and administering a unit, he should be required to impart the three level objectives into his thinking and planning.

Under the level of aims, the members of the seven cardinal principles[2] which are directly or strongly indirectly administered to by pupil participation in the activities of the unit should be listed along with a short explanation as to how they are administered to by the unit. The second level objectives may conveniently include the general objectives, such as the

[1] National Society for the Study of Education, *Thirty-First Yearbook Part I; A Program for Teaching Science*, 153.

[2] Committee on reorganization of Secondary Education, *United States Bureau of Education, Bulletin 1918. No. 35.*

development of attitudes, skills, interests, and general knowledge objectives which are likely to be achieved during the unit. The third level of objectives should embrace the specific knowledges which the pupils are expected to acquire during the unit. These may be in a statement form giving the central idea of each major problem or in the form of a clause introduced by the preposition "to" as shown in the sample lesson plan.

Immediately following the statement of the specific objectives, the major problems may be stated in the form of a question or problem which are merely a restatement of the specific objectives. This form provides a transition and correlation of the major problems with the objectives. Pupil activities through which the objectives are to be reached may logically follow the major problems. These activities may be listed in detail or in an outline form as given in the sample plan. It is suggested that the beginning student teacher lists the specific experiments, sketches, problems for discussion and reports—of course, the guide or study sheet must be prepared in detail.

Next in importance are the teacher activities. The list of teacher activities will depend upon the type of unit, but regardless, whether the lesson is pupil purposing, compulsion, or socialized recitation the teacher has important duties to perform, as listed in the sample plan.

References and materials should be listed in detail, so that the student teacher may have a list to which ready reference may be made, in order to bring efficiency of teaching to the optimum level.

ADMINISTRATION OF THE UNIT

The administration phase of the unit envelops the detailed daily plans, giving the objectives and detailed procedures for each period, throughout the duration of the entire unit. The attached sample plan illustrates in a brief outline the pattern which may be followed. The general plan of administration employs the Morrison technique,[3] namely: (1) Exploration, (2) Presentation, (3) Assimilation, (4) Organization, and (5) Recitation.

The paramount portion of the exploration period is the administration and interpretation of the pre-test. The pre-test may be given either orally or written depending upon the time of the period and psychological states of the teacher and pupils.

[3] Morrison, H. C. *Practice of Teaching in The Secondary School*, U. of Chicago Press, 1926.

It may be in three forms: (1) objective and comprehensive, similar or the same as the mastery test, (2) semi-objective, with many questions involving brief answers, and (3) subjective in character, with a few broad questions involving long general answers. The two last types may be administered either written or orally with great satisfaction. The content and administration of the unit should be modified if necessary according to the findings revealed by the pre-test.

The presentation should be an interesting, sensational, brief survey or preview of the material in the unit which will arouse the pupils' interest, curiosity, and zeal to do honest work on the unit activities. It should be saturated with demonstrations, illustrations, slides, models, and moving pictures wherever possible. A cooperative pupil and teacher planning period may culminate this overview.

A brief presentation of problem one should follow the unit presentation or overview. This should include necessary directions and more definite pupil-teacher planning for successful solving of the problem. Supplementary projects, reports, excursions and activities which may be done by a pupil, committee or the class as a whole may be planned and assigned for this problem and future major problems.

A tentative, brief planning of each problem presentation will practically complete the organization phase of the unit lesson plan. The sample lesson plan includes the pre-test, presentation and mastery tests in the administration phase of the plan. There may be controversy over the placement of these parts of the plan.

The guide or study sheet is headed with the unit theme and followed by the major concept. The objectives which are significant to the pupil and may help in motivation and understanding for the pupil may be listed if the teacher desires, but these objectives must be stated in the language of the pupil and from the standpoint of the pupil. Clear, definite and brief directions should be given in the assignment. Following these directions the statement of each major problem with minor problems or exercises following each problem indicating the minimum requirements and suggestions for extra work for the brighter pupils makes up a functional guide for the pupils. Further work for the brighter pupils may be suggested at the end of the guide sheet. The writer has learned through experience that ninth grade pupils achieve better results if extra

work is provided for each problem so that the group may be kept together more closely permitting group presentation for each major problem. Eleventh and twelfth grade pupils are more capable of successfully executing the long assignment and extra work need only be suggested or provided at the end of the study sheet.

The preparation of the mastery test and problem tests, or check-up tests, may classify itself under the organization phase of the unit, but is placed here because of convenience. The mastery test is to check to see if the specific objectives have been achieved. It should be an objective, reliable and valid test. The writer has found ideal a minimum essential mastery test which all pupils are expected to complete. Extra credit items are added for the brighter and more capable pupils. The problem tests may be similar to the mastery test, but shorter because they cover only one problem of the unit. The mastery test should be administered when all pupils have completed the minimum study requirements, and when minimum mastery is practically certain so that a minimum of remedial work is necessary.

The organization step may be done by each individual pupil or by committees. Occasionally an oral organization may relieve the monotony of a too often employed written summary.

During the recitation step, a larger number of participants may be acquired if the slower pupils are called upon to give the story of the unit as there will be more opportunity for corrections and additions.

Each plan needs to be modified according to the needs of the pupils and teacher.

SAMPLE LESSON PLAN

Unit Organization

I. Unit theme: The earth is an insignificant part of the universe.

II. Major Concept: The earth on which we live is a small body among millions of other heavenly bodies some of which have a great influence on this earth of ours.

III. Objectives.

A. Aims.

1. Worthy use of leisure time: The pupil may become interested enough in the stars to pick out the ones he knows on night walks and to study further about the heavens.
2. Vocational: This interest may be carried out in later life to the extent of adopting astronomy as a life-work.
3. Ethical character: Contemplation of the vastness, complexity, and perfect order of the universe cannot help but lead to a broader understanding of his own position in relation to the rest of creation on the part of the pupil.

B. General.
1. Knowledge of subject matter which leads to an understanding of the universe.
2. Discovery and development of correct study habits, abilities, skills, through correct analysis of text, use of diagrams interpreting figures, symbols, careful reading and thinking.
3. Attitudes toward environment to help students realize the value of a study of the heavens.
4. Wholesome interests developed through a desire to find out more about the heavens.

C. Specific.
1. To learn how the universe is organized.
2. To know the nature of heavenly bodies.
3. To know how stars can be located.
4. To know how the earth is affected by heavenly bodies.
5. To know how position on the earth is located.
6. To know how standard time is determined.

IV. Major problems.
A. How is the universe organized?
B. What is the nature of heavenly bodies?
C. How can the stars be located?
D. How is the earth affected by heavenly bodies?
E. How is position on the earth located?
F. How is standard time determined?

V. Pupil Activity.
A. Written answers to questions on guide sheet.
B. Diagrammatic sketches of constellations, phases of the Moon, etc.
C. Observing and performing experiments and demonstrations.
D. Special reports on phases of the unit, current astronomical news, etc.
E. Class discussion.
F. Independent study out of class.

VI. Teacher activity.
A. Prepare and administer pre-test.
B. Give presentation of unit.
C. Provide and administer work on guide sheet.
D. Lead class discussions.
E. Plan and perform experiments.
F. Encourage study outside of class.
G. Provide special references.
H. Test results.

VII. References and Materials.
A. Text.
B. Additional references.

Unit Administration

I. Exploratory cycle or approach.
A. Objectives.
1. To discover what pupils already know.
2. To motivate further study.

B. Procedure.
Administration of the following pre-test orally during latter part of the period. Short discussions should be held on questions brought up by pupils, emphasizing importance of getting final answers while studying the unit.

1. What is the nature and origin of the earth?
2. What is a planet? Is the sun a planet?
3. Do all planets revolve around the sun?
4. Of what is the sun composed?
5. How many kinds of heavenly bodies are there?
6. How many planets are there? Name as many as you can.
7. What is the moon? What causes it to change its appearance?
8. What is the difference between stars and planets?
9. What is a constellation?
10. Name some constellations. How did they get their names?
11. Do the stars move?
12. How could you find a particular star?
13. Do you know of any manner in which the earth is affected by heavenly bodies? Are people affected?
14. What causes changes in season?
15. What time is it now in New York? In China?
16. How do we find "correct" time?
17. Does the sun always rise in the east and set in the west?
18. What is an eclipse?
19. Do you think there is any danger of the earth's being hit by another heavenly body?
20. Would you like to be an astronomer?

II. Presentation or (Planning cycle).

A. Objectives.

1. To give the pupils an over-view of the unit.
2. To motivate study.
3. To give some appreciation for the great wonder of the universe.
4. To aid in pupil planning.

B. Procedure.

1. Have a model of the solar system before pupils on demonstration desk.
2. Give the following presentation during first part of period:

We usually think of the stars as being far away and not affecting our lives very much, but study of their movements have come to be of great importance to all of us. The day upon which your next birthday will fall, for instance, depends upon the movement of heavenly bodies. Important as this subject is, it was not until comparatively recent times that much was known of it. Before men learned what the stars really were and what governs their movements, they invented myths and superstitions to explain what was for them a great mystery. Many of these superstitions grew into religions. I am sure that all of you have read at some time of sun worshippers. The early Greeks and Romans named the stars and planets for their Gods and Goddesses of which they had a plentitude. By the time of the Middle Ages, enough observations had been made of the movements of stars and planets for learned men to be able to tell when a star or planet would appear in a certain section of the sky. It was at this time that the superstition of astrology was popular. People believed that their lives were determined by the position of the stars in the heavens at the time of their birth. We know today that there is no truth in this superstition. It was not until men began to search for

reasons in the heavens that the science of astronomy was born. The principle of the telescope was discovered by a Dutchman named Hans Lippershey, in 1609, and Galileo, an Italian of the same period developed it into an instrument with which he was able to study the heavens more closely. The sun and moon are of course the most important of the heavenly bodies to man because they are the closest and best known. But the sun cannot be said to be very close to us for it is 92,000,000 miles away from the earth. Around the sun revolve the earth and other planets, and beyond the sun and planets lies the immensity of the universe where distances are too great to be measured by miles. Out there, the speed of light which travels 186,000 miles a second is used to measure the space between bodies. Light from the nearest star, Aldebaran, requires 44 light years to reach the earth. The actual effect of heavenly bodies on the earth, distant as they are is felt in changes of season, tides and many other ways.

III. Assimilation. (6½ periods)—See Guide Sheet.
  1. Last half of second period.
    a. Objectives.
      (1) Acquiring of knowledge.
      (2) Interest in organization of universe.
    b. Procedure.
      (1) Present Problem No. 1 and plan with pupils the special activities for the next period and future periods.
      (2) Hand out guide sheets.
      (3) Supervised study on Problem No. 1.
  2. Third period.
    a. Objectives.
      (1) Knowledge.
      (2) Appreciation for mysteries of space.
      (3) Appreciation for scientific method in learning facts about universe.
    b. Procedure.
      (1) Class discussion on Problem No. 1.
      (2) Special topics on Problem No. 1.
      (3) Preview on Problem No. 2.
      (4) Supervised study of Problem No. 2. (Problem No. 1 due.)
  3. Fourth period.
    a. Objectives.
      (1) Knowledge.
      (2) Appreciation for beauty of stars.
      (3) Attitude of awe toward order in heavens.
    b. Procedure.
      (1) Topics on Problem No. 2.
      (2) Discussion of Problem No. 2.
      (3) Preview of Problem No. 3.
      (4) Supervised study on Problem No. 3. (Problem No. 2. due.)
  4. Fifth Period.
    a. Objectives.
      (1) New knowledge.
      (2) Clarify old knowledge.
      (3) Find out where corrective measures are necessary.

b. Procedure.
(1) Review of what has been gone over (short written test).
(2) Experiment to show distribution of light and heat during different seasons.
(3) Supervised study on Problem No. 4. (Problem No. 3 due.) Let pupils select topics and projects on Problem No. 4.

5. Sixth period.
a. Objectives.
(1) Knowledge.
(2) Skill in diagramming.
b. Procedure.
(1) Topics on Prob. No. 4.
(2) Preview of Prob. No. 5. Let pupils select topics and projects on Prob. No. 5.
(3) Supervised study on Problem No. 5. (Prob. No. 4 due.)

6. Seventh Period.
a. Objectives.
(1) Knowledge.
(2) Appreciation of effect of celestial movement on earth.
b. Procedure.
(1) Topics on Prob. No. 5.
(2) Discussion on Prob. No. 5.
(3) Preview of Prob. No. 6. Arrange topics and projects on Prob. No. 6.
(4) Supervised study on Prob. No. 6.

7. Eighth Period.
a. Objectives.
(1) Knowledge.
(2) Review.
b. Procedure.
(1) Topics on Prob. No. 6.
(2) General review of what has gone before.
(3) Clearing up of any questions and finishing of necessary remedial work.
(4) Questions on Prob. No. 6 due.

8. Ninth Period.
a. Objectives.
(1) Find out what pupils have learned—degree of mastery.
(2) Evaluate teaching.
b. Procedure.
(1) Administer mimeographed mastery test on unit. (about 30 minutes.) (See test on last page.)
(2) Have pupils exchange papers and score test.
(3) Discuss test and remedial work. (10 min.)

IV. Organization. (Tenth day.)
A. tenth period.
a. Objective.
(1) To organize and summarize material taught during unit.
(2) To aid pupils in understanding and retaining functional parts of unit.
b. Procedure.
(1) Have each pupil write an organized summary of the information acquired in the unit without any references. (about 30 min.)

V. Recitation
  A. Last part of 10th period.
    a. Objectives
      (1) To further clinch materials of the unit.
      (2) Give pupils opportunity for self expression.
      (3) To have pupils hear the story of the unit re-told.
    b. Procedure.
      (1) Ask for volunteer to give the summary to the class or call upon pupil.
      (2) Have rest of pupils supplement omitted material and criticise the summary.

GENERAL SCIENCE GUIDE SHEET

I. Unit Theme—The earth is an insignificant part of the universe.
II. Major Concept—The earth on which we live is a small body among millions of other heavenly bodies some of which have a great influence upon this earth of ours.
III. Assignment. Read text, Chapter XI.
  A. Write answers to questions in the following problems, and hand in each set of answers on the day following their assignment.
    a. Problem No. 1. How is the universe organized?
      1. Tell what is meant by "The Heavens."
      2. Describe the solar system.
      3. Describe the sidereal system.
      4. Is the solar system a part of the sidereal system?
      5. Which system do you think is most important? Why?
      6. Name the planets in order from the sun.
      7. Name some important stars.
      8. How near is the closest star? The farthest?
      9. What force holds the earth and planets near the sun?
      10. What is the shape of the earth's path around the sun?

    Extra Credit—Make a copy of the diagram on page 149.
    b. Problem No. 2. What is the nature of the heavenly bodies?
      1. Tell all you can about the size of the earth.
      2. Describe Wilson's theory of the composition of the sun.
      3. Kirchoff's theory. Which is generally accepted?
      4. Why do we have 1 a year?
      5. Tell all you can about the size of the sun.
      6. How big is the moon?
      7. What is a lunar year?
      8. Of what are the stars composed?
      9. Make the diagram on page 154. What is meant by phases of the moon?
      10. Why do stars twinkle?

    Extra Credit—Make a diagram of a cross section of the sun according to Wilson's theory.
    c. Problem No. 3. How can the stars be located?
      1. What is a constellation? Name eight of them.
      2. What is the "fixed star"?
      3. How can we find the important constellations by means of fixed star?
      4. Describe the constellations, Great Bear and Casseopeia.
      5. How did the constellations get their names?
      6. Describe the Milky Way.

    Extra Credit—Make the diagram on page 163.

d. Problem No. 4. How is the earth affected by heavenly bodies?
   1. What is the function of the sun?
   2. Explain why we have changes of season.
   3. What season is it in Argentina during our mid-summer?
   4. What causes changes in length of day and night?
   5. Does the sun always rise in the east?
   6. Describe a solar eclipse.
   7. What are tides? What causes them? Explain flood tides and ebb tides.

Extra Credit—Make a diagram illustrating the position of the earth at different seasons.

e. Problem No. 5. How is position on the earth located?
   1. What is the difference between latitude and longitude?
   2. Where and what is the prime meridian?
   3. How many degrees and miles are between each parallel of latitude?
   4. How many parallels are there? How many meridians?
   5. Explain how to find location.

Extra Credit—Find the latitude and longitude of La Crosse.

f. Problem No. 6. How is Standard Time determined?
   1. What is meant by solar time? Solar day?
   2. What is civil time?
   3. Why do places to the east of us get the sunlight earlier?
   4. How much difference is there in the time of sunrise on meridians 15 degrees apart?
   5. What is standard time and why is it necessary?
   6. Describe the time belts in the United States.

Extra Credit—Write an essay on the international date line—(See Hodgdon)

B. Extra Credit.
   1. Write one of the talks in class.
   2. Describe the origin of the earth.
   3. Make a drawing showing planets according to their size and including all satellites.
   4. Chart the constellations described in this chapter.

REFERENCES.

Bowden, General Science.
Hodgdon, General Science.
World Book Encyclopedia.

MASTERY TEST—THE HEAVENS

True-false (Mark plus (+) at the left of each true statement and zero (0) similarly for each false statement.)

1. Astrology is still studied by many scientists.
2. Constellations are groups of planets.
3. The constellations first received their names from Myths many of which were named by the Greeks.
4. Astronomy is a truer science than astrology.
5. Venus is the nearest planet to the sun.
6. The "terrestial planets" are Mercury, Venus, Earth, and Mars.
7. Our solar system is made up of only the sun and planets.
8. We do not know more about the heavens because parts of them are too far away to be studied with the telescopes we have.
9. Many suns in the heavens are much larger than the sun in our solar system.

10. If there are any more suns in our solar system we have no proof of it.
11. An eclipse of the sun takes place during new moon.
12. The sun revolves on its axis.
13. The sun is about twice as large as the moon.
14. Solar eclipses occur more often than lunar eclipses.
15. An eclipse of the moon is visible over a large part of the earth at one time.
16. Tides are caused chiefly by the sun's pull of gravity.
17. The phases of the moon refer to what shape the moon appears to be.
18. Spring tides are high tides which occur only in the spring of the year.
19. Our solar system occupies a large part of the entire universe.
20. An "ellipse" is the moon at first quarter.
21. Gravity is the force which tends to hold the heavenly bodies in their orbits.
22. The moon revolves about the earth and keeps the same side toward us.
23. The sun is thought to be composed of incandescent gas.
24. The "inclination" of the earth refers to its attraction for the sun.
25. An ebb tide is a rising tide.
26. The earth is the largest planet in the solar system.
27. It is believed that the meteorites are composed of hot gases.
28. The moon is one-fiftieth as large as the earth.
29. The sun and stars shine both day and night.
30. A lunar year is 29½ days.
31. The length of a year on all planets is 354½ days.
32. The seasons change because of different positions of the earth as it moves around the sun.
33. The earth is part of the sidereal system.
34. Latitude is the distance in degrees north and south of the equator.
35. It is known that all sides of the moon are pitted with craters.
36. There is a different in time of two hours for every 25 meridians.
37. The solar year is divided into 354½ days.
38. Some stars are smaller than the earth.
39. When it is winter in La Crosse it is spring in Argentine.
40. Stars are farther from the earth than the sun is from the earth.
41. The earth is the smallest part of the universe.
42. Stars are composed of burning gases.
43. Sunrise and sunset are caused by the revolution of the earth on its orbit.
44. The vernal equinox falls on March 21.

Completion. Fill in the blanks.

1. The shape of the earth's orbit around the sun is an .....
2. When the sun, moon, and earth are in a straight line we have ..... tides.
3. During ..... moon we have lunar eclipses.
4. The four ..... of the moon are ....., ..., ..., and .....
5. The ..... waves are caused by the force known as .....
6. The ..... of the earth's ..... causes change in seasons.
7. The shadow of the earth causes eclipses of the .....
8. Because the moon has no ..... it is a ..... body.
9. One would weigh less on the other ..... because they are less ..... than the earth.
10. A planet ..... on its axis and ..... about the sun.
11. ..... is the largest planet in our solar system.

12. The Milky Way is the same as the .....
13. Three kinds of heavenly bodies which make up our solar system are ....., ..., and .....
14. Heavenly bodies which can be seen by their own light are called .....
15. The planet known as the earth's twin is .....
16. The fixed star is also called the ..... star.
17. The earth revolves on its ..... and travels along a certain part or .....
18. The heavens are composed of two systems, the ..... and the .....
19. Days and nights are of equal length during the months of .... and .....
20. When it is 6 O'clock in Boston, it is ..... O'clock at La Crosse, and ..... O'clock at or in San Francisco.
21. The moon appears to change shape because of .....
22. Tides are caused by the ..... of the ..... and the .....
23. The nearest star is ..... light years away.
24. The largest known star is called .....

RECALL TEST

1. Name five planets.
2. Name two values of tides.
3. Name three constellations.
4. What is standard time?
5. How is the knowledge of the heavens of most value to us?
6. What is the Milky Way?

EXTRA CREDIT

1. Show how we have phases of the moon.
2. Describe Kirchoff's theory.
3. Describe fully any constellation.
4. Describe two planets.
5. Tell how to find the fixed star.

BRAIN WAVES ARE CONSISTENT

Brain waves are consistent. Moods and mental activity and accomplishment may vary from day to day, but not the wavy lines on paper that tell scientists about the electrical energy that accompanies activity within man's brain.

The day-to-day consistency of a person's brain waves is reported by Drs. Lee Edward Travis and Abraham Gottlober of the State University of Iowa to the journal *Science*. These brain-probing scientists recently reported that one person can be distinguished from others by his brain waves.

Brain waves vary according to whether a person is sleeping or awake and working at mental problems or awake and just sitting idly with nearly "blank" mind. The latter condition is the one in which the Iowa scientists made their studies. Brain wave records taken day after day from the same person were so consistent that they could be identified as belonging to that person just as different samples from one record could be identified in the earlier studies. Presumably the same consistency will be found in a person's brain waves during sleep or mental activity.

ADVOCATING A FUSION OF PHYSICS AND CHEMISTRY

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It is the purpose of this paper to describe a science course which is intended to replace the conventional physics and chemistry courses as they are offered today. In this one, the important concepts of both physics and chemistry are fused and presented as related material.

There are many advantages to be had by the adoption of such a *fused course*, and it will be the writer's intention to present some of the reasons for its existence before outlining and describing the course itself. There has been the criticism of both the chemistry and physics courses that when taught as such, there is a great deal of duplication at the college level. Professors of chemistry in our colleges have been heard to remark that they would rather have pupils who have not had chemistry in the high schools as it is now presented to them. Their criticism is based upon the fact that in high school, these subjects are made highly technical and the pupil feels as though his college work should be more interesting and yet finds merely a duplication. The result is that he usually loses interest, fails to apply himself and consequently does inferior work.

There seems to have been two aims around which most of the contention and criticisms have arisen. The first was that chemistry and physics were intended to prepare the pupil who did not go on to college. By inference, one would assume that these courses in themselves had distinct vocational training. That is absurd for there are no industrial jobs of any importance for which high school training in either chemistry or physics would be adequate. Preparation for college has also been taken as an objective. The conventional method of chemistry teaching has been criticized by both parents and teachers and a report of this has been made by the Committee on Chemical Education[1] in 1924. The study of some thirty thousand criticisms in this report gives the preparation for college as the chief aim and thus places much of the more worth while material outside of this nucleus required for university or college entrance. If training for college entrance is really important, one

[1] Committee on Chemical Education. Standard Minimum Course of High School Chemistry. *Journal of Chemical Education, 1*, 1924.

would think that it would help most, the student who planned on going into scientific work, probably medicine or industrial chemistry. Forty-eight deans[2] (or about two-thirds of the Class A medical schools) of medical colleges responded to a questionnaire and they were about evenly divided in thinking that Chemistry, Physics, Biology and Zoology be given only in university and not at both levels, high schools as well as in university. This would seem to indicate that the conventional types of science courses at the secondary level are not entirely serving their purpose if that purpose is to prepare pupils for college work.

There are a few who believe that courses must be difficult, abstract, highly theoretical in order to serve their purpose in the schools. Hedrick[3] after expounding on the desirability of teaching things from practical standpoints asks these questions, "Shall I lower the standard of instruction in a theory if I give real comprehension of its meanings? Shall I destroy the beauties of a scientific achievement if I give men insight into its connection with realities?"

Most all of the sciences seem to be in a static condition. Certainly that is true of physics also, for its teaching has seen but little change since the time of the Committee of Ten. Physics as a college entrance subject has been so firmly entrenched that teachers have had little opportunity to do more than follow rather definite courses of study based only on factual material and laws which college professors deemed necessary as a basis for further achievements in college physics. The very nature of the textbooks themselves is retarding the progress of good teaching and this of course reflects upon the conventional courses of study that have been followed. This can be said of both chemistry and physics and a questionnaire[4] given to some five hundred teachers from the better schools of the country bears out this statement. Both the chemistry and physics courses have won for themselves sufficient dissatisfaction on the part of all concerned to actually warrant a change.

There have recently appeared two chemistry texts that demonstrate some of the newer trends in the organization of subject

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[2] Kefauver, Grayson N. and Mackenzie, Gordon N. "The Value of Secondary School Subjects in the Preparation for Medicine." *California Quarterly of Secondary Education, VIII*, pp. 159–171.

[3] Hedrick, Earle R. "Science Teaching as a Service." *California Quarterly of Secondary Education, VIII*, pp. 367–370.

[4] Hunter, G. W. and Edinger, O. H. "Methodology in Science in Junior and Senior High Schools." *Science Education*, February, 1933.

matter. One is "Units in Chemistry"[5] by Howard and the other "Dynamic Chemistry"[6] by Biddle and Bush. Both of these have their contents arranged in units and treat the subject very well. Many more practical, common place illustrations are used by which to explain the various principles than were in use several years ago. The unit system of attack is advocated by many for the reason that it allows a well organized grouping of closely related material under a common background or heading. This is certainly superior to some of the old type texts which were merely an accumulation of disconnected chapters wrapped together between two covers. Some interesting physics texts have appeared too. Millikan, Gale, and Coyle have just published a "New Elementary Physics"[7] which is also organized on a unit system and embodies many modern illustrations and examples. Fletcher, Mosbacher, and Lehman have written an interesting text, "Unified Physics."[8] It is not organized on a unit basis but is particularly interesting in that it unifies nearly all of its concepts under the topic of matter in motion. These texts represent decided trends but in the opinion of the writer, each could be made to serve better their function at the secondary level by omitting much of the purely factual, and theoretical material and in that way allow space and time for explanations in terms of the other sciences. In other words, omit some of the impractical and technical chemistry in order that the pupil might be allowed an association with some of the more important concepts of physics which would aid the explanation.

Wilson[9] has just brought out a half-year chemistry course and a half year of physics. Wilson is to be complimented on his attempt to improve the courses but he has done so by more or less reducing the content of the text sufficiently to allow its completion in half the usual time. He makes a statement in the preface of his text which is well worth noting. " . . . this means freedom to demonstrate pet experiments, to tell stories about the great men of science, to develop hobbies, to dwell on this topic, to omit that, and, in general, to teach and to inspire

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[5] Howard, Russell, S. *Units in Chemistry*, New York: Henry Holt and Company, 1934.

[6] Biddle, Harry C. and Bush, George L., *Dynamic Chemistry*, New York: Rand McNally and Company, 1936.

[7] Millikan, Robert Andrews, Gale, Henry G. and Coyle, James P. *New Elementary Physics*, New York: Ginn and Company, 1936.

[8] Fletcher, Gustav L., Mosbacher, Irving, and Lehman, Sidney, *Unified Physics*, New York: McGraw-Hill Book Co., 1936.

[9] Wilson, Sherman R. *Descriptive Chemistry*, and *Descriptive Physics* New York: Henry Holt and Company.

the pupils. There are no valences and formulas to be taught, no problems to be solved, no equations to balance, and no college entrance requirements to be met." This certainly illustrates the trend again but Wilson's set of two texts *should not be confused with the fused course which this paper introduces. A fused course* not only presents the fundamentals of each course but fuses or integrates them, teaching them at the same time that they may be more meaningful and may show the pupil how they are related. It will also show the pupil just how closely all the other sciences are related.

In developing a course incorporating a fusion of both chemistry and physics, it is necessary to select the units[10,11] through which or by means of which only the important concepts of both subjects are to be presented. If these are to find their places in the syllabus on the merit of their interest and current popularity both in news and in the magazines, one might choose them by a careful survey of the field. Several studies of this kind have been made. The selection of units for this *fused course* was not done on the basis of any of these researches for most of them are rather old. With the rapid scientific advances, it is easy to see that new inventions, new discoveries, and new applications have come to the front and for that reason, a new survey would need be made. It is for that reason too, that science texts and references so quickly become antiquated and made obsolete.

In selecting the units to be studied, it was also necessary to bear in mind the concepts that would have to be fitted into the scheme. Watson[12] made an interesting study in which he found that 659 parents of Kansas High School students listed twenty-three items which they considered important in their daily life and which were not considered in the high school physics text. This means that it would be rather useless to make a thorough survey of the current texts in an effort to set up standards of concepts and theories which must be covered in this *fused course*. There not only is much omitted that should be there but there is obviously much material given which would be later reviewed and duplicated in the college work and

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[10] Morrison, Henry C. *The Practice of Teaching in the Secondary School*, Chicago: University of Chicago Press.

[11] Howard, R. S. "Some Aspects of the Unit Method of Teaching Chemistry." *Journal of Chemical Education. Vol. VIII*, No. 5, 1931.

[12] Watson, C. H. "A Critical Study of the Content of High School Physics with Respect to Its Social Value." *School Review*. November, 1926.

for that reason need not necessarily be considered essential. It seems that a much better plan is to select a number of units which seem to represent the important elements of interest in the current press, daily conversation, and present-day industrial advances. In this case, two units are especially selected by which to conclude the course. These are not necessarily more difficult than the rest but are purposely chosen because they, better than any others, allow the pupil to understand and explain the things included in them in terms of the many concepts which have preceded. This seems to be in line with our accepted educational theories which conclude that a real test of mastery is the pupil's ability to apply what he has learned in a new situation. All of the twenty untis may be defended and explained by our best scientific principles. *In this way, any material included explains its presence by virtue of its explanatory function. If some concept which ordinarily is found in conventional texts is omitted, then again its omission is excused on the basis that it is not found useful or necessary in the explanation of current science topics.*

Below is listed the units which have been chosen. They have been named here in their hard, uninteresting terminology in order that the reader will quickly grasp the sequence and at the same time sense the scientific concepts and principles that will probably accompany each. As the units are presented in the syllabus, they will be more interestingly worded.

1. Air Conditioning. 2. The Motor Car and the Railroads 3. The Petroleum Industry. 4. Mining and Metallurgy. 5. Printing and Typing. 6. Illumination and Photography. 7. Microscopy and the Telescope. 8. Aviation. 9. Munitions. 10. The Manufacture of Paper. 11. The Water Supply. 12. Sewage Disposal Systems. 13. Radio, Movies, Television. 14. Telegraph, Telephone, Teletype. 15. Civil Engineering. 16. Glass, Gems, and Plastics. 17. Checking Food Producers and Manufacturers. 18. Scientific Methods and the "G" Men. 19. Weather Predictions. 20. How to become an inventor (applying scientific method).

Whenever really interesting topics are discussed or explained in textbooks, you usually find them well hidden in the back of the book. Few, if any, ever find their way past the middle. The reason for this is clear when one realizes that in the conventional type of course, the subject matter is taken up in a so-called logical order. Each item principle, theory, or fact is explained thor-

oughly and completely. So completely in fact, that when all the chapters have been covered this mechanical way and not before, the pupil should be prepared in his physics or chemistry and be able to apply some of that knowledge to practical use. He has probably been taught a great number of things about a few theories and laws. In other words by the conventional method he becomes a specialist in each law and principle as he progresses.

In nature it is more than rare—it is never—that a problem, question, tool, device, modern convenience, or any phenomena occurs which can be explained by any single theory, principle, or law. Why then should it be logical to present subject matter in this uninteresting manner? The authors of these other texts would probably answer that it is impossible to explain any of these so-called current topics without a knowledge of many of these fundamentals at hand. That is true, but it is surely not necessary to make use of each of these fundamentals, completely and exhaustively.

This means that the interesting topic of "Air Conditioning" in this *Fused Course* might well be presented to the pupils even as an introduction. Through an investigation of it, air itself might be discussed. The composition of it could be explained. Even the fact that it was a mixture, rather than a compound, would be enlightening. It would not necessarily follow that the pupils at this time should understand, or even know, the details about electrons, protons, valence, and so on of the various atoms. It might be advisable to use this opportunity to distinguish between mixture, compound, molecule, and element but there is no need to get highly technical. Surely, in the next unit, possibly in every unit, there will be some opportunity to mention atoms, carbon dioxide, water, gas, evaporation and the like. Let each meeting in this fusion be an opportunity for extended knowledge of these items. This plan will have many advantages, some of these are as follows:

1. It allows the pupils to study interesting and significant material all the time and not only in the last chapter or two.
2. The explanations and principles are never long but always brief, practical, and to the point thereby explaining only what is needed as it is needed.
3. Each principle is developed throughout the series of units and not exhausted the first time met.
4. The constant relationship and integration of all these topics is constantly demonstrated.
5. This provides constant review as well as a constant testing program

as the items are met in new and unusual situations throughout the book.

6. It provides a better introduction to college science and also serves the pupils who do not go on to higher education.

On the following pages, one of the units in this *Fused Physics-Chemistry* is described briefly. It is always necessary that there be a certain amount of interesting story or even fiction surrounding and enveloping the various topics. Some of these are interesting to the pupils for their reading whereas each should be of interest to the instructor. As an indication of some which are available and well suited, a few are listed in connection with the unit outline to which they belong. A constructive unit has been chosen in order to demonstrate that there is a continuation or carry-over in the various elements of the explanations and overlapping of different topics.

UNIT ONE

What Places Should Be Air Conditioned?

References: (as first unit, may include some general articles as well).

"Dispelling Popular Fallacies About Air Conditioning." L. R. Smith, *Scientific American*, Vol. 151: 86.
Some of the most difficult aspects of this industry are cited. The complexity and expenses of the apparatus are discussed as well as the methods by which the difficult results are actually accomplished. It is proven to be an industry and not a fad.

"The Breath of Life." Charles C. Stewart, *Atlantic Monthly*, Vol. 155: 348.
An article beginning with a simple discussion of buoyancy and gradually working up to breathing in fish as well as in some land forms.

"Conditioned Air?" Philip H. Smith, *Scientific American*, Vol. 155: 80.
An interesting article telling of the newer concepts, the trend of designs, and the present status of this industry. It is filled with illustrations and includes some of the problems of house heating as well as house insulations.

"Chemistry and Daily Life." Dr. Chas. Stine, M. A., *Scientific Monthly*, Vol. 37: 541.
Describes a few striking examples of the tremendous importance of some of Dupont's contributions and developments. New industries, modern methods, synthetic materials, and new markets are listed as results of modern industrial chemistry.

"On Radiating Surfaces." Harold D. Babcock, *Carnegie News Service Bulletin*, Vol. II.
A short article which shows how Kirchoff's Law may be proved. It describes methods of taking pictures of hot objects using only their heat energy for the purpose.

"Near Absolute Zero," J. G. Crowther, *Scientific American*, Vol. 151: 300. (1934).
This gives an interesting description of the method and apparatus by which scientists have been able to get within one-twentieth of a degree Centigrade of their goal of absolute zero, −273°C. or 459°F.

"Dr. John Gorrie, Inventor of Artificial Ice and Mechanical Refrigeration." John Gorrie, *Scientific Monthly*, Vol. 42: 464.
This includes drawing and photographs of early patent pictures as well

as the original machine. It tells how he came to invent the machine and also describes the mechanics of it.

"What is Scientific Proof?" L. Swann Harding, *Scientific American*, Vol. 53: 192.

This article attempts to show how different the average person's conception of proof is from truly established scientific proof. The most common mistakes are discussed and goes on to tell what the demands of the hard-boiled, cold, logical scientists are. Scientific proof is most difficult to establish but is well worth the effort.

"This Unscientific Age." Robert L. Duffus, *Harper's Monthly*, Vol. 170: 68.

This article in an interesting manner presents a challenge. It contends that the present day people are more conscious of scientific information and scientific achievements but that they are no more scientific in their mode of thinking than ever. He contends "That careful and critical knowledge which is called science must be applied to all fields of human activity or we shall eventually find it applied to none. . . ."

"The Scientist in an Unscientific Society." Henry A. Wallace, *Scientific American*, Vol. 150: 285.

This article contends that inasmuch as society has to live enslaved by science as well as helped by the progress of it, it would be only just that a scientist be put in command.

(A reply to the above article), *Scientific American*, Vol. 151: 77.

In this a number of prominent scientists give their views on Secretary Wallace's contention. These show the thoughts and emotions of the scientist of today.

"Detecting Carbon Monoxide." Alexander Klemin, *Scientific American*, Vol. 155: 95.

Short but interesting article on the dangers of this gas. There is a graph to show what small concentrations are necessary to effect its content in the blood and also the accompanying effects it has on the individual. Devices for readily determining these concentrations are mentioned.

CONTENT OF UNIT ONE

Discussion of the modern applications of air conditioning in many situations.

Installation in homes, office buildings, churches, theaters.
Used in private cars, motor busses, trains, and aeroplanes.
Needs in mines, factories.
Now they air condition orchards too.

Present subject of *air*.

Its *Composition*.

What is *oxygen?*
What is *nitrogen?*
What is *carbon dioxide?*
What is *argon?*
What is *water?*

Show *simple tests* for some of these.

This presents meaning of *combustion*.
This presents meaning of the term *inert*.
This presents meaning of *properties*.
Both *chemical* and *physical*.
Lime water test for *carbon dioxide*.
Describe new tests for *carbon monoxide* with Palladium, activated iodine pentoxide, or combustion.

Allows for explanation of difference between:
Element, substance, compound, and *mixture*.

Explain what is meant by *humidity.*
Describe *washing* of *air.*
Introduce topic of *evaporation.*
Briefly show relation of
heat to *solids, liquids,* and *gases.*
Additional opportunity for check on *substances, elements, compounds, mixtures.*
Introduce *molecules* briefly.
Explanation of *relative humidity,* dew point, cause of *rainfall* may be briefly introduced (not for complete mastery).
The item of *measurement* and its meaning should be taken up.
Illustrating by such devices as *hydrometers, psychrometers,* etc.
Explanation of *heat.*
Again show methods of its measurement.
Review Relationship to *transition* of *solid, liquid* and *gas.*
Discuss methods of *transferring heat.*
These will include *convection, conduction, radiation.*
Description of methods of *producing heat.*
These will include *compression, electrical resistance, chemical action, friction.*
A discussion of various types of *furnaces, stoves, fireplaces, heaters, reflectors.*
Differentiation between the term *heat* and *temperature.*
Review again what is meant by *measurement.*
This will bring up the discussion of several types of *Thermometers.* (Don't try to include them all as such would involve to many principles.)
Explanation of what is meant by *cold* or lack of *heat.*
Review Concepts of *evaporation* again.
Explain it on the basis of its connection to *refrigeration.*
Demonstration of other methods of producing *cold.*
Adiabatic *expansion* shown but not technically explained.
By the application of *chemical action.* (Again, only a demonstration but no technical explanation.)
Discussion of *hygienic, biological,* and *physiological* effects of various aspects and contents of *air.*
Sickness from chilled *air.*
Poisoning from *carbon monoxide.*

NEW HIGH SPEED WIND TUNNEL

America is catching up with Germany in high speed wind tunnels which can test sub-stratosphere aviation conditions, Dr. G. N. Lewis, director of the National Advisory Committee for Aeronautics, told Science Service.

The announcement that Massachusetts Institute of Technology will build a ten-foot diameter tunnel that will simulate conditions at 35,000 feet altitudes and speeds of 450 miles an hour, Dr. Lewis, said, brings additional aid to the similar equipment which the NACA is already building at Langley Field.

Both wind pressure tunnels, pointed out Dr. Lewis, follow the general plan and design of the wind tunnel of the Reich Air Ministry at the University of Goettingen at Hannover, Germany.

The rarefied atmosphere and accompanying low air pressures encountered in the sub-stratosphere, where aviation now would like to do its flying, render inaccurate some experimental findings obtained in previous wind tunnels at ordinary atmospheric pressure.

A STRONG MOTIVATION IN CHEMISTRY

By Charles H. Stone
Boston, Massachusetts

From time to time doubts arise in the writer's mind as to whether the traditional approach to the study of chemistry is really the best one. True, it is the historical method; modern chemistry had its beginnings with the discoveries of Cavendish and Priestley. But that argument is not sufficiently strong to preclude the thought that some other way might be of equal or even of better value.

All of his short life, Johnny Beginner has been accustomed to things which he can both see and feel, air excepted. Now, almost at the beginning of his study of chemistry, we plunge him into an entirely new world where he is expected to deal with intangible substances, the gases, which he can neither see nor feel. However much these various gaseous substances may differ in their chemical properties, oxygen, hydrogen, carbon dioxide, sulphur dioxide, ammonia, present the same physical appearance to the budding chemist. It would be of little interest to him to make a collection of these intangible substances for, with the exception of chlorine and nitrogen dioxide, all gases look alike.

Now it is natural for animals from squirrels to men to hoard, to make collections. Every youngster will have his bag of agates, his collection of birds' eggs, of rocks and minerals, of movie and baseball stars, of cigar ribbons and various other things. Stamps, of course, are to be included. Cafeteria spoons and hotel towels have not been entirely neglected by the older generation. Why not, then, begin the youngster's introduction to chemistry by starting him off with a utilization of his already acquired knowledge and natural instincts? Let him work for a while with tangible substances yielding tangible products, products having definite color, shape, and so on. One may well begin with the sulphides. Lead, copper, and iron sulphides are easily made by direct union of the elements. And, lest the beginner gets the idea that all sulphides are black, let him prepare white zinc sulphide, yellow cadmium sulphide, orange antimony sulphide, and red (or sometimes green) mercury sulphide; not all of these by direct union of course. Here at least he will have something tangible to show for what he has done which is a perfectly natural desire not only for beginners in chemistry but for older folk as well, even as you and I.

This article is not to say that we should abandon the usual procedure in the laboratory; far from it. It is only to say that the introduction of the intangible gases might be made a bit more gradual and natural. When oxygen has been prepared and studied, then may follow the examination of other oxides than mercury oxide in order to determine whether they, too, will yield oxygen when heated. Or the beginner may prepare a number of oxides, colored by preference, such as lead oxide from lead nitrate, copper oxide from copper carbonate, cadmium oxide from cadmium carbonate. These he may add to his collection of self-made materials. Indeed, when we think of it, the usual experiments in the laboratory, if carried to their logical conclusion, provide opportunity for the recovery of some very definite and tangible materials; potassium chloride and manganese dioxide from used "oxygen mixture," zinc sulphate form the residues in the hydrogen generator, calcium chloride from the preparation of carbon dioxide, and beautiful copper nitrate from the preparation of nitric oxide.

Sometime just start Johnny on the experiment to recover in a reasonably pure condition the two forms of zinc sulphate; it will pay. But how many laboratory manuals do you know which instruct the student to do that? Do they not, all too frequently, leave the experiment before its logical end has been reached to engage in another experiment in which the same procedure is repeated. The by-products do not seem to concern the writers of many of the manuals now on the market. Enough zinc sulphate is thrown away every year in any school laboratory to supply the entire needs of the school; no teacher ever need buy any. We throw away the by-product and then spend good money to buy some of the same thing. What is the matter with our common sense? Chemistry ought to be and is a perfectly logical subject but the procedure followed in some of our manuals does not seem to be consistent. Why the writers of these manuals pay so little attention to the recovery of the by-products of an experiment is beyond the power of the writer—feeble minded perhaps—to understand.

Now the preparation of tangible substances, of materials which the student can preserve and exhibit forms a strong motivation in chemistry. The opportunities for such work along quite elementary lines are almost unlimited; ample material is at the hands of any teacher who cares to use it. The preparation of matches which will really light when scratched

on the prepared surface, rubber from latex, a number of pigments for coloring paint, a simple dye and its application to wool or cotton, solid alcohol, barium chloride from witherite, lead nitrate from lead oxide (litharge), antimony chloride from stibnite, and a variety of beautifully crystallized salts by neutralization are just a few of the products which any student of ordinary ability may easily make.

The writer has been much amused on several occasions when visiting a school and asking the chemistry instructor this question: "What are your pupils doing in the way of simple preparations?" to receive this answer: "Oh, we don't do anything with that! It's way over their heads, you know." Well, it isn't way over their heads, you know. All of the above mentioned substances and many others have been made in my laboratory by first year students, not all by any one student. They have been made by first year students in other schools where I have been privileged to come into close relations with individual students. They can be made in any school by any student of average ability. All that is needed is an opportunity for the pupil to show what he can do under the teacher's guidance.

No pretense is made as to the high purity of these various products. C. P. quality can hardly be expected of Johnny Beginner. But in many instances the product is good enough for class use in the average experiment and is placed in a suitable container, properly labelled and bearing the legend: "Made by Johnny Q. Beginner" and set upon the shelf for use whenever there is occasion. It is at any rate a promising beginning.

It is not the writer's thought that work of this character should displace or supersede the regular work of the laboratory; but it does seem that something of this sort now and then can most effectively be used; it serves to "pep up" the work as well as serving to show the pupil how what he has already learned can be applied to the preparation of a large number of interesting substances.

When Johnny sees one of these experiments in the offing, just watch him. Here at last is the real thing! When he starts out on some small project with a very definite and tangible result as the end to be attained, he will go at that experiment like a puppy at a root. And if, when he has completed his project, you suggest that he assemble all related materials and make an exhibit of them, you will see the smile that won't come off. And when that exhibit is placed in the show case in the corridor,

you can't tell me that Johnny isn't pleased, and none the less because his Kodak face appears in one corner of the show card. And best of all, he can, by and by, take that exhibit home to show to "Pop" and "Mom" saying: "Lookit! I made it myself in Mr. Bonedd's class in chemistry!" Ah, that is the life.

There are those who will say: "But this is play and not real work!" Well, I've heard that one before. Listen. Play is what you *like* to do; Work is what you *have* to do, willy-nilly. When what you have to do becomes a pleasure it is no longer Work but Play and none the less to be valued on that account. Now I ask you,—you are not on oath of course, but so help you Johnson—how much better is it for Bill to do an experiment that somebody has wished onto him, or to engage in a self-selected experiment with a very tangible end in view? I thought that was what you would say! I say, yes! Well, anyway, here are three experiments on glass.

A. Etching. (For Bill, but no restrictions on its use by others.) One trouble with the etching experiment as given in the usual manual is that it is too perfunctory. The pupil scratches his name on a small square of glass; there is nothing particularly interesting about that. Who wants to look at "J. W. Wombat" on glass or anywhere else. Instead let the pupil make his own choice: Mutt and Jeff, Moon Mullins, figures from some fashion sheet, a piece of chemical apparatus, or a really fine design such as a piece of mountain scenery or a ship at sea. Better even than that, let the pupil, if he has artistic talent, prepare his own design. Only line drawings should be attempted; half tones and photographs are no good for this work. My own pupils have made some very beautiful designs which are still on exhibition at the school. Glass large enough to cover the design, with its twelve edges dulled with a flat file, should be provided. Do not limit Johnny as to size; give him a window pane if necessary, but usually a piece about 4×6 will be large enough. Waste glass can often be obtained at the glazier's shop for nothing.

Spread a large sheet of newspaper on the desk and stand a ring stand in the center of it. On asbestos gauze on ring of stand melt some paraffin in an evaporating dish. If the brush to be used is stiff with the wax, put that into the dish too so that when ready to use it will be soft and pliable. Do not heat the paraffin till it smokes, but just enough to make it liquid. Meanwhile warm the glass on the steam radiator or high up over a small

flame. Apply the melted wax to one side of the glass, using the brush and covering all parts of the surface. Warm the glass again and let all the paraffin that will do so drain back into the dish. This procedure will coat the glass with a very thin layer of the wax. Many teachers and pupils apply too much wax making a coat that is quite thick. When the glass is cold, lay it wax side up on the drawing to be copied. With any sharp point: awl, large needle, or even a sharp-pointed pencil with hard lead, trace the lines of the drawing, cutting down to the glass. Blow away the loosened wax.

Pour about 5 ml of liquid hydrofluoric acid into a small porcelain crucible. Dip a small brush, or a piece of cotton rag tied to the end of a stick, into the acid and brush all parts of the drawing with the acid. *Do not inhale the fumes nor get any of the acid on the hands.* Finally, immerse the glass in a pan of hot (not boiling) water to melt off the wax. Remove the glass and wipe dry with a cloth. Traces of wax may be removed with carbon bisulphide or tetrachloride.

Now for the mounting. In the shop have a slit cut lengthwise of a three inch strip of board, the slit being near one edge and slanting a bit toward the back. This strip can then be cut up into pieces of any desired length. Select a suitable strip, fill the slit with mucilage or shellac or other adhesive, press the glass, etched side to the front, into the slit and wipe away any adhesive which may ooze out. In a short time the glass will be fixed in position. If the pupil's name was not etched into the glass, it may be printed with ink on the wooden base or written on a sticker which is then attached to the base.

When the stopper is replaced in the bottle of acid, be sure that it is sealed in so that no fumes can escape to frost the bottles standing near on the shelf in the store room.

B. Silvering. (For Jane, but no restrictions.) Prepare two solutions.

1. Dissolve 80 grams granulated sugar in 700 ml distilled water. Add 175 ml alcohol and 3 ml conc. nitric acid. Make up to one liter. This solution should be made at least a week before it is to be used; it improves with age.

2. Dissolve one gram silver nitrate crystals in 100 ml distilled water. Add dilute ammonium hydroxide until the precipitate which forms just dissolves. Now add one-half gram potassium hydroxide dissolved in 50 ml of distilled water. Cautiously now add dilute ammonium hydroxide, drop by drop

with shaking, until the brown precipitate almost but not quite dissolves.

Be sure the tube to be silvered is perfectly clean; it is best to use a new tube. Into a small beaker pour 20 ml of solution 2, and 4 ml of solution 1. Stir well with clean glass rod and pour into the clean tube. Let stand in rack for fifteen minutes. The liquid will first turn black and then the silver will appear. Pour out the liquid and rinse the tube. Drain dry. A little melted paraffin or shellac may be poured into the tube which is then rotated so as to line the whole inside with the protective backing. Polish the outside of the tube.

The beaker may be cleaned with a little very dilute nitric acid.

C. Frosting. (For anybody.) There is on the market a paste which can be used for inscribing initials on windshields of cars. It is called Etchal. Clean and warm the glass. Warm the stencil which comes with the paste, warming the sticky side, and press the stencil firmly upon the glass; press all edges down hard against the glass using any smooth roundish material, such as the bowl of a spoon. Squeeze out some of the paste from the tube and with a small brush or swab work the paste into all parts of the stencil. Do not let any paste touch the glass outside of the stencil. After five minutes, wash off the paste under the faucet, warm the glass and stencil gently and carefully peel off the stencil. The initial will be found neatly etched.[1]

Such experiments as these, and many others introduced from time to time form a strong motivation. Not only do they serve to stimulate the student who undertakes them, but they also serve to urge on the less able or idle student. I have often been approached by some mediocre student with the question: "May I try some of those extra experiments?" The answer was: "Sure, Henry, but you will have to get some of your back work caught up first!" And this is the comeback. "You just watch my dust!"

[1] Etchal may be procured from the Etchal Company, 24 E. Twenty-second St., New York City Fifty cents brings a tube of the paste with stencil for any desired initial. One tube will do a dozen cars.

LIQUEFIED GASES USED IN GERMAN MOTOR CARS

Gases from the German coke industry, compressed into liquid form in high-pressure cylinders, is now available as a motor car fuel. Simply opening a valve releases the fuel in gaseous form, to be mixed with air and introduced into the cylinders. Each cylinder contains the fuel equivalent of about 15 gallons of gasoline. The gases used are propane and butane.

THE PROFESSIONAL TREATMENT OF FRESHMAN MATHEMATICS IN TEACHERS COLLEGES

PART I

BY EUCEBIA SHULER

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ANALYSIS OF PROFESSIONAL TREATMENT

The question of professional treatment of subjectmatter is one which concerns specifically teacher training institutions. For the last fifteen or twenty years this question has been receiving increased attention. Interest in the plan for making content courses for teachers more professional may be credited largely to Bagley who has aroused enthusiasm through his many writings and to Randolph[1] who has given the best historical survey of the field.

What is professional treatment of subjectmatter? The answer to this inquiry involves a number of things, such as: attitude, originality, psychology, history, and educational values. It implies a conscious attempt to make teaching a real profession with standards comparable with those of other professions as law and medicine; however, the real burden of the problem lies in the handling of the subjectmatter. The content courses are not to be weakened but strengthened through wide margins of knowledge, broad visions of the subject and a scholarly rigorous treatment of those materials appropriate to the needs of the teacher. The knowledge derived from such a course "will throb with life and meaning," it will reveal its relation to human experience,[2] and it will manifest its capacity for enriching the lives of people. One may possess information including all of the characteristics named above and still not be able to impart properly this knowledge to others, hence professionalized subjectmatter must not only contribute to a teacher's "professional stock-in-trade" but must at the same time introduce the prospective instructor to the principles and the technique of teaching.[3] For example, it is imperative that a teacher be able to see

[1] E. D. Randolph, *The Professional Treatment of Subject Matter*, Baltimore, Warwick and York, Inc., 1924.

[2] William C. Bagley, "Twenty Years of Progress in the Professionalization of Subject-matter for Normal Schools and Teachers Colleges," *N. E. A. Proceedings* (Department of Teachers Colleges), 1928, *66*, 906.

[3] Alfred L. Hall-Quest, *Professional Secondary Education in Teachers Colleges*, Teachers College Contribution to Education, no. 169, New York, Bureau of Publications, Teachers College, Columbia University, 1928, 92.

where special difficulties arise and how to handle them, and to be able to think through the materials in his own field in the light of future problems in teaching.[4]

A general definition of professional treatment of subject-matter may then be summarized as that treatment of content courses which best develops in the teacher a scholarly understanding and a broad vision of the subjectmatter, and which at the same time develops the art of adapting and using those materials in teaching others.

In the light of the above definition it was desired to determine the status of freshman mathematics in teachers colleges, and to propose a plan for applying professional treatment to the content courses. Three sources of information were chosen: literature, representing expert opinion; 1932–33 catalogs, as typical of general practice among standard teachers colleges offering a major in mathematics; and inquiry blanks which called for the details of what is actually being done along this line.

LITERATURE ANALYSIS

A study of the literature written by those interested in the professional treatment of subjectmatter shows a general agreement with regard to the salient features of the program. The discussions may be grouped around the following points which will be briefly reviewed.

Professional Attitude. Practically all writers voice the opinion that this plan is something much broader than curriculum offerings and requirements; it must include first of all a professional attitude, an enlightened growing conception of the service of the educational system, and a keen interest in the teacher training problem with the needs of the prospective instructor always in mind. This attitude on the part of a college faculty creates an "atmosphere" and an earnest professional spirit such that the entire institution is directed toward one definite specific purpose. This spirit will be felt by the students and it will make them conscious at all times of the goal toward which they are working. This is the key to the whole situation. The ideals of scholarship and professional fitness must go hand in hand; knowledge of subjectmatter must be acquired with reference to its professional use; and the prospective teacher must become sensitive to his own future teaching problems while acquiring

[4] Charles C. Fries, "The Training of Teachers: The Problem of Professionalized Subject-matter," *Educational Administration and Supervision* (1927), *13*, 183–189.

the content.[5] At no time is the importance of sound scholarship or thorough mastery of knowledge to be given less attention; in fact, it is to be emphasized more, not in the narrow bounds of isolated facts but in as many of its relationships and functions as possible.

Psychology of the Subject. Giving attention to the psychology of the subject while mastering its contents is not a modern idea; it has been advocated for some time. The substance of a discussion by Parsons,[6] in 1887, is that psychology is not something brought from without and artificially superimposed but it is most helpful when acquired in the mastery of the subject itself. There are many practical situations in which a student may be taught to analyze his method of thinking through the subject, of organizing data, building up arguments, and drawing conclusions. When that person later teaches he is likely to think back in his experience and reconstruct the steps in his own learning process and apply them to his instruction.[7] Such an analytical view of a subject will contribute much toward the great function of mathematics—teaching a method of thinking. If one is unable to analyze his own learning procedure it is difficult to conceive of his being able to diagnose the psychological difficulties of his students, follow their mental itineraries, guide them out of their intellectual fogs, and lead them into paths of clear reasoning through which they may develop good thinking habits.[8]

Methods and a Reexamination of the Elementary Subjects in the Light of Higher Studies. The method of teaching a subject cannot be separated from the psychology of that subject; they are so closely related to each other and to the content that they have meaning and value only in terms of the subjectmatter.[9] It may be said that method is the effective or psychological treatment of material; then no better application of the principles of method can be found than through a critical reexami-

[5] Randolph, *loc. cit.*, 127–129.

[6] W. W. Parsons, "Discussion," *N. E. A. Proceedings* (1887), 507.

[7] C. C. Fries, "The Training of Teachers: The Problem of Professionalized Subject-matter," *Educational Administration and Supervision* (1927), *13*, 183.

[8] Heber Hinds Ryan, "Pupils" Learning Difficulties as a Basis for Teacher-training," *Educational Administration and Supervision* (1933), *19*, 220.

William S. Learned, William C. Bagley, and others, "The Professional Preparation of Teachers for American Public Schools." *Bulletin* No. 14. *Carnegie Foundation for the Advancement of Teaching* (1920), 183.

H. W. Nutt, "A Fundamental Weakness in Teacher-Training Courses." *Educational Administration and Supervision* (1926), *12*, 200–218.

[9] William C. Bagley, "Professors of Education and Their Academic Colleagues," *The Mathematics Teacher* (1930), *23*, 285.

nation of those topics of high school mathematics which are also taught on the college level. The coordination of the material on these levels will enhance both. One of the most practical and helpful aspects of this type of procedure is the light which the advanced work will throw on special difficulties which may be diagnosed and avoided in future teaching. The fact that method is considered a part of professional treatment does not mean that all aspects of it are desirable or appropriate to a freshman course, but there are many educators who agree that emphasis and attention should be given to those points of method which can be handled effectively in the content courses.

Analysis of Textbooks. One of the best means of enriching a course is the use of supplementary texts. A freshman will need to be familiar with books treating topics on his class level in order to broaden his margins of knowledge and to enrich the study. To make the materials on the college level function in high school he must also know something of high school texts. There is much that one may learn by comparing the methods of presentation, development, and arrangement of proofs in various books; by determining which presentations are more suitable, more exact, and why; by giving attention to such questions as: which text best fits the needs of the students using it, which presents the most logical or psychological sequence of topics, what are the advantages of certain omissions and rearrangements, and what could be done to a certain high school text to enrich it.

History of the Subject. Teaching the history of the development of the subject along with the subject itself has long been practiced in varying degrees and methods, and it is one of the chief points of emphasis in the professional treatment of content material. Students and teachers need to know and appreciate the historical development of the subject, and to understand the way in which that subject has influenced the world's thought, progress, and welfare.[10] The one who has brought to the attention of mathematics teachers in particular the value of historical material is Professor David Eugene Smith; he not only encouraged its use but, as far back as 1903, he recommended two years of it in the professional education of teachers of mathematics.[11] The history offers suggestions for overcoming

[10] William C. Bagley, "Professors of Education and Their Academic Colleagues," *The Mathematics Teacher* (1930) *23*, 286.

[11] D. E. Smith, "Does the Teacher's Knowledge of a Subject Differ from the Scholar's Knowledge," *N. E. A. Proceedings* (1903), 558.

difficulties in teaching, throws light on individual topics as they are studied, and gives material that prospective teachers may use later as instructors.

History of the Teaching of the Subject. Closely associated with the history of the subject is the history of the teaching of it. Literature on the historical development of methods, however, is very meager, and one is dependent to a great extent on old textbooks for this information, but a study of this phase of a subject is very interesting and is the basis of much helpful information for the teacher-to-be. In the freshman year this part of professional treatment would not extend beyond an analysis of different methods of arriving at solutions, comparison of different arrangements of topics, development of fundamental concepts, and noting improvements and changes made in the teaching procedure. Later on the student will be able to go into this more fully, making a more thorough study of types of reasoning employed in the development, the principles of psychology underlying the changes in methods, what methods have survived and are still effective and why, formulating for themselves what they think are the best methods applied to certain topics, and justifying their conclusions.

The chief value, of course, in such a study lies in "enabling the prospective teacher to evaluate new educational proposals"[12] and theories and to determine what may be the best materials and procedures. If for each subjectmatter field there were a history of the methods of teaching it, and the underlying conditions accompanying the periods, there would be much less confusion and dissatisfaction concerning attempts to put into practice some of the proposals often found in the field of education.[13] This historical record of methods would make it possible to plan a more continuously progressive educational program by evaluating the practices that failed or succeeded in the past.[14]

Educational Values. A teacher is frequently asked to justify his subject on the basis of educational values. Why study mathematics? Where and when can it be used? There are satisfactory answers to these questions which instructors in the subject should be prepared to give, and other answers than those justifying the practical side for the average layman. One

[12] Randolph, *op. cit.*, 47.

[13] *Ibid.*, 47.

[14] Percival M. Symonds, "Subject Matter Courses in Mathematics for the Professional Preparation of Junior High School Teachers." *Educational Administration and Supervision* (1921), 7, 76.

of the greatest values to be derived from the study of mathematics is a knowledge of and an ability to apply the mathematical or scientific mode of thinking. Such a value is more than simply practical; it is cultural as well. The aim and purpose of professional treatment is better preparation for the teacher; and that teacher whose knowledge is broad and scholarly instead of narrow and superficial will have an appreciation of the subject that is genuine; he will know something of what it has meant to the world, and what it has contributed to other fields of scholarship; he will see its relationship to more advanced work in the field and the light that it throws on the more elementary work of the same field; he will know something of the necessary skills and habits for satisfactory work; and he will realize through the subjectmatter his indebtedness to the past and the obligations placed upon him for large and effective living.[15] He will also know something of the professional values, the new lines of endeavor both in content and method; in short he will know as much as possible of the whole nature of mathematics in its broadest aspects.

Any course may be handled in such a way as to be narrowly vocational or an instrument of liberal culture; it all depends on the manner of approach and presentation. The teacher needs the vocational as well as the cultural aspects of the subject and these two viewpoints are combined in professionalized subjectmatter.

Acquaintance with the Literature of the Subject. It may be impossible for one to become acquainted with all the literature of the subject studied, but to be reasonably familiar with the most important literature, past and present, requires no justification. Further than this, a teacher should know how and where to find information on his subject, and how to sift the important from the unimportant and trivial.

Familiarity with Characteristic Problems and Standards of Achievement. Familiarity with characteristic problems and standards of achievement in the field should be included in the general information of the teacher, but this item of professional treatment is not appropriate for a course in freshman mathematics since it is usually beyond the experience and training of first year college students.

Originality and Creativeness. Originality and creativeness are not only very desirable but necessary qualities for a good teacher

[15] Hall-Quest, *op. cit.*, 94.

of mathematics, and they should be fostered from the beginning of the freshman year. It is doubtful whether those powers can be created, but it is possible to develop them in students who have the innate ability to think along original and novel lines.[16] Such opportunities are justified since the expression of the pupil's own individual initiative is his greatest contribution and since they provide a more enriched course for the brighter portion of the class.

Observation in the Demonstration School. The training school is the laboratory for teacher training and should be used to the greatest advantage throughout the student's course. All of the professional treatment discussed so far may be concretely demonstrated in the training school and, thereby, remove much of the vagueness concerning the *how* of applying these principles to actual high school teaching. Observations of lessons in the training school probably will have little value for freshmen inexperienced in teaching, but such exercises as choosing examples for explanation and demonstration of a principle, noting dependence and sequence of topics, distinguishing fundamental and subsidiary concepts, selecting appropriate means of approaching a topic, and considering values in different methods of developing ideas, will go far toward preparing a student for the problems he will have to consider in writing and using lesson plans.

Professionalization of the Library. The professionalization of the library needs no argument or justification. It goes without saying that if anything along the line of professional treatment of subjectmatter is to be accomplished, the library must provide access to books and materials for the assistance of students and teachers.

Demonstration of Professional Treatment in the Freshman Class. The power of example is greater than that of words and theories; teachers teach largely as they were taught, for this reason it behooves the teacher to practice in his teaching those things which he advocates for others. If the college teacher lectures, or uses the laboratory method, so will the students when they teach. If the college instructor uses professional treatment of subjectmatter there will be much in the way of general principles that may be carried over into high school teaching, at least the general procedures of teaching should be

[16] Edna E. Kramer, "Some Methods in Professionalized Subject Matter Courses in Mathematics for Teachers Colleges," *The Mathematics Teacher* (1931), *24*, 432.

largely transferable.[17] For example if the instructor of freshman mathematics requires his students to analyze the learning process, to learn something of the history of the subject, to be able to determine principles and fundamental concepts underlying the work, and to know and appreciate the value of mathematics is he not demonstrating general procedures which are as desirable for the high school teacher as for the college instructor?

From the previous discussion it may be seen that professionalized courses differ from liberal arts courses chiefly in attitude, purpose, method of approach, and selection and organization of materials. The professional content courses focus the attention of students and instructors on the need and the preparation of prospective teachers.

The present status of professionalized subjectmatter is far from ideal but the changed attitude of some of the schools and faculties toward the idea, the studies and applications that have been made, the clearer conception of the meaning of the term, the recent growth of the four year teachers colleges, the success with which some colleges have carried out the program, and the growth of a general interest in and sympathy for the plan have all shown a definite trend toward professionalized subjectmatter courses.

CATALOG ANALYSIS

A detailed analysis of the course descriptions of mathematics found in the catalogs of the teachers colleges showed that except for a few institutions which have a definite professionalizing program, only a small percentage of the content courses receive professional treatment. Besides those points which were found in the literature on professional treatment of subjectmatter the catalogs gave the following which are probably self explanatory:

1. Plan the teacher training course as a unit to get continuity of learning.
2. Link the content of the course with the mathematics which precedes and which follows.
3. Specify desirable habits, skills, and attitudes.
4. Give a liberalizing and broadening contact with other fields of scholarship.
5. Show the manner in which mathematics has affected the thinking of the present day.

[17] A. W. Hurd, "Professionalization of Subject-matter Courses in the Education of Science Teachers," *Educational Administration and Supervision* (1933), *19*, 175.

6. Use special topics, reports, or projects when advisable.

One of the strongest arguments in favor of such a program is the success with which some colleges have been able to put it into effect.

QUESTIONNAIRE ANALYSIS

The results of the questionnaire give much more encouraging information as to what is actually being done to make freshmen subjects more useful to the teacher. The items which received the highest scores were: the attempt to link the content of the course with the mathematics which precedes and which follows; giving attention to the principles and fundamental concepts underlying the work, warnings of pitfalls and how to avoid them; professional attitude, or learning with the view of teaching always in the foreground of the consciousness of teacher and pupil; opportunity for originality and creativeness on the part of the pupil; extra margins of material, planning the course as a unit; and practicing good teaching in the freshman classroom. All of these items were used by more than 85 per cent of the colleges who responded to the questionnaire. An average of 21.4 items or 63.8% of the points covered by the information blanks was used by each college in an effort to professionalize the first year of college mathematics.

It seems reasonable to believe that the inquiry blanks give a more reliable measure of the present status of professional treatment of subjectmatter than the course descriptions of the catalogs, since some catalogs present only the titles of courses with little or no indication of the content and the treatment.

CONCLUSIONS

The main points which are emphasized in professional content courses may be summarized from the preceding discussion. A general scheme derived therefrom may be applied to the subjectmatter of any course; but to give a concrete illustration of this procedure and to suggest some of the possibilities of professional treatment in freshman mathematics, the following discussion will apply the points of this plan directly to the quadratic function.

It is not advocated that *all* of the material given or suggested be used in a first year course. It is thought however that from these possibilities a teacher may select, adapt and present the most appropriate and useful of these means to his individual classes and use others as supplementary material for the bright students.

RECENT ACHIEVEMENTS IN COLOR PHOTOGRAPHY*

By Herbert H. Johnson
Eastman Kodak Co., Rochester, New York

Processes of color photography all date back to the classic experiment of Clerk Maxwell before the Royal Institution, London, in May, 1861. On this occasion Maxwell demonstrated that any shade of colored light could be produced by combining various amounts of three primary colors, red, green, and blue-violet. He used three separate lanterns and placed colored solutions before the lens of each. Ferric sulfocyanide was used for the red solution, cupric chloride for the green, and an ammoniacal solution of copper sulfate for the blue. When the light from all three lanterns was projected on the same spot on the screen, a white area appeared; when the red and green beams were superimposed, a yellow spot was obtained; with red and blue, a magenta spot, and with green and blue, a blue-green spot. This is called the additive method of color synthesis, and is the basis of the so-called additive methods of color photography.

Eight years after Maxwell's demonstration a small French booklet was published in Paris written by Louis Ducos du Hauron. This contained a description of almost all the basic principles of color processes which have subsequently been worked out. Credit should therefore be given this French inventor for his foresight. In the intervening years until his death in 1920, he continued to experiment and work out further details of color processes, but was unable to realize much commercial success from any one of these methods.

Of the many references published on color photography, Wall's "History of Three Color Photography," which was published in 1925 is perhaps the most valuable, since it represents a compendium of information on all phases of the subject.

Color processes are generally divided into two types, the additive and the subtractive. With the additive process the actual red, green, and blue colors are either separately visible in the film itself or are formed by an optical system as with Kodacolor. These primary colors are projected onto the screen for viewing in such a way that they are added together by the eye. Additive

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* Lecture delivered before the General Science Section of the Central Association Meeting in St. Louis, Nov. 27, 1936.

methods include Kodacolor, color screen plates such as the Autochrome, Finlay plate, Dufaycolor and others.

Any possible color on the screen can be formed by additive combinations of the primary colors, red, green and blue.

Likewise they can be formed by proper combinations of the colors which are complementary to the additive primaries. The complement of red is blue-green, of green is magenta, and of blue is yellow. These complements are sometimes referred to as the minus colors thus:

Primary Color	*Complementary Color*
Red	Blue-green called minus red
Green	Magenta called minus green
Blue	Yellow called minus blue

Subtractive processes form their colors by combining the three complementary or minus colors. The minus or subtractive colors simply absorb the corresponding primary color from the projection beam of light.

If we put a blue-green, which is to say, minus red filter or dye deposit, into a white light beam, the red will be absorbed and the beam will appear blue-green.

If, now, we add a magenta (minus green) filter to the blue-green filter mentioned above, both the red and the green light will be subtracted from the white light beam. The only light left to go on through is blue. Similarly any color may be formed by suitable superposition of layers of the subtractive colors in various densities.

The new Kodachrome process is a subtractive process. The colors of the original subject are visible in the finished positive. In all subtractive color prints the three separate subtractive colors are superimposed. Usually three separate negatives are made through the three primary filters, and prints are made from these in dyes complementary to the taking colors, and then superimposed on one support.

The important point that makes Kodachrome different from other color processes is the fact that instead of making the three negatives on threee separate films, they are separated in the depth of one film. Kodachrome film is coated no less than five times! Nearest the base an emulsion is coated which is extremely red-sensitive. On this is a very thin coating of gelatine. On top of this is coated a second layer of emulsion which is

strongly green-sensitive; over this is coated a second coating of gelatine containing a blue absorbing eye, and finally, on the top, is coated an emulsion which is blue-sensitive.

Kodachrome film resembles a three-layer cake with the frosting left off the top layer. The three layers of emulsion are represented by the three layers of cake. The gelatine coatings between the bottom and middle and between the middle and top are represented by the frosting. All five of these coatings combined are no thicker than an ordinary black and white film.

The exposed film is developed by the reversal process used for the past twelve years for black and white 16 mm. photography. In developing Kodachrome, an image corresponding to the blue component of the subject is formed in the top layer, that corresponding to the green in the middle layer, and that corresponding to the red in the bottom layer. These images are then converted into dyes the colors of which are complementary to the colors by which they were made: top, yellow; middle magenta; bottom, blue-green. The finished color images are perfectly registered one over another.

There is no mechanical registration to give blurred pictures; there are no lines or screen pattern on the film and no graininess. The wonderful life-like naturalness of Kodachrome pictures makes one feel as though he were looking out through an open window at real life.

I am sure after you see some of the pictures which we are now going to project, that you will agree that Kodachrome is the greatest achievement in color photography thus far. It is impossible to predict the future of this process, but the possibilities appear to be unlimited.

WORLD'S BIGGEST OYSTER-SHELL

Biggest oyster-shell in the world is the distinction claimed for an enormous fossil, four feet long and three feet wide, dug up by geologists of the National Park Service in the proposed Big Bend National Park area, in western Texas. Dr. Charles N. Gould, who has been working in the rich fossil deposits of the region, thinks there may even be bigger shells waiting to be excavated.

Another "biggest" fossil discovered in the Big Bend country is a ten-foot petrified tree. No other tree of that size, living or fossil, has ever been found in Texas. The region is also rich in fossils of dinosaurs and extinct elephants.

A DEMONSTRATION ON LABORATORY TECHNIQUE IN HIGH SCHOOL CHEMISTRY

By Erwin Pfefferkorn
Waupun High School, Waupun, Wisconsin

Most students have seen their instructors perform experiments and use such apparatus as is found in the average chemistry student's locker. When the student himself uses the apparatus he lacks the technique that was unobserved when he saw the materials used. It is well that the students be made acquainted with simple laboratory procedures before they are sent into the laboratory. It is to avoid costly mistakes in the use of apparatus as well as loss of time due to personal injury that the following demonstration may well precede initiation into laboratory work.

Rather than write up the demonstration in the conventional experiment form, the following discourse takes up the subjects as demonstrated by the instructor as well as related questions and associated topics. Many of the topics follow each other as a natural sequence as a result of using previous apparatus.

1. Bunsen Burner.

All students know that to light a Bunsen Burner we open the gas jet and light the burner. Sometimes the gas pressure is too high and the sudden release of gas blows out the match. It is best to draw the lighted match downward toward the top side of the burner.

When a burner strikes back, it is burning at the base with a hissing sound and the gas should then be turned off immediately. Continued burning in the base of the burner results in the base getting so hot that the rubber connection begins to burn. Readjust the gas and air intakes and relight the burner so it burns with a quiet flame.

2. Cutting Glass Tubing and Rods.

Either glass tubing or rods can be conveniently cut by taking a three-cornered file and scratching the glass at the desired place. With the scratch up, lay the tubing on the file so that the scratch is directly above the file corner. Apply pressure to either side of the scratch and the glass will break at the scratch.

Another convenient way of separating the glass at the desired scratch is by placing the thumb nails just opposite the scratch and applying pressure to break the tubing. The broken

ends of the tubing are very sharp. How can they be rounded?

3. FIRE-POLISHING.

Heat the end of a glass tube in the oxidizing part of a flame until the flame begins to be distinctly colored yellow by the tube. Do not overheat, as continued heating will eventually close up the hole and render the glass useless as a tube. Why does heating eliminate the sharp edges? (Look up in a physics book on the subject of surface tension.)

A glass rod can be fire-polished in the same manner as the glass tube. Why does it take much longer? The glass rod you have now fire-polished can be used as a stirring rod. A piece of glass tubing is unfit as a stirring rod because the inside of the tubing cannot be conveniently cleaned.

4. INSERTING GLASS TUBING, RODS, AND THISTLE TUBES INTO STOPPERS.

Serious injury may result if dry glass tubing is pushed into a dry rubber stopper. Wet the fire-polished tubing in water, and if possible, use the tubing as a pipette and let the water run into the stopper hole. This will lubricate the stopper and prevent the tubing from being broken. Apply the turning pressure with the hands as near as possible to the stopper.

When tubing is to be inserted into a two-hole stopper, insert the shortest one first. If a thistle tube is to fill the second hole, grasp the thistle tube by the wetted stem near the stopper and rotate. It is sometimes advisable to take the thistle tube out of the stopper and rewet for a second time if the tube is to be inserted nearly full length in a stopper.

5. REMOVING STOPPERS FROM TUBING, RODS, ETC.

Especially when stoppers become hot, they will tend to stick to the inserted rod or tubing. Always remove tubing from stoppers at the close of an experiment. When it is necessary to remove a "stuck" tube, do not try to twist it out—set the tubing at right angles to the table and push down by applying pressure parallel with the tubing and with the thumbs on the stuck stopper. If this method fails, discard the stopper to avoid injury.

6. PUTTING RUBBER TUBING ON GLASS RODS AND TUBING.

In general, the same procedure applies to rubber tubing as to rubber stoppers. The glass rod or tubing should be fire-polished and wet before it is inserted into rubber tubing. When rubber tubing is put on a glass tube somewhat larger than the tubing diameter, e.g., distilling tube connection, it is best to

turn the tubing inside out for a quarter of an inch and then let the "snapping back" of the rubber tubing aid in getting the tubing over the glass rod or tube.

7. Rubber and Cork Stoppers.

A simple method by which hardened rubber stoppers can be softened is by placing the stoppers on the floor and "rolling" them underfoot with considerable pressure. Commercial apparatus is available for this purpose, but for the average high school laboratory the simple method will suffice.

When cork borers are used, it is best from the standpoint of stability to start boring on the small end of the cork.

8. Using Liquid Reagents.

(a) *Removing Glass Stoppers.*

Granting that the stopper is not stuck, place the hand, palm up, over the stopper so the stopper can be lifted up by placing it between the fingers. This method keeps the stopper clean and off the table. A dirty stopper will then not be put back into the bottle and neither will the table or clothes be ruined by corrosive chemicals. By this method both hands are free to manipulate apparatus, though the stopper is held between the fingers.

(b) *Pouring from Reagent Bottles.*

Grasp the bottle so that the label is up when you pour. What effect does improper technique in pouring have on paper labels?

Keep the graduate or receiving vessel at near eye level for accuracy in measurement.

Avoid resting on or touching the receiving vessel with the container from which you are pouring as this may contaminate the original liquid.

(c) *Excess Liquids.*

Don't have any! Be accurate in your first measurement, but if you do, do not pour them back as you might spoil the purity of the original liquid. Test tubes and graduates too often are not clean.

(d) *Diluting Acids.*

Remember the rule—Always pour acid into water. Reversing this will cause the acid to spatter upon the sudden release of heat.

9. Weighing Chemicals.

If two chemicals, e.g., MnO_2 and $KClO_3$, are to be weighed, zero your scale to the weight of the paper on which the chemicals

are to be placed. Both chemicals can be weighed on the same paper, if after weighing out of say 3 grams of MnO_2, the scale slider is pushed ahead 6 grams to accommodate the $KClO_3$. This saves time when a limited number of scales is available.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

LATE SOLUTIONS

1475. *Isadore Chertoff, Bayonne, N. Y.*

1472, 3, 7. *G. S. N. Ayyar, Tiruvilwamala, India.*

1478. *Proposed by Cecil B. Read, Wichita, Kansas.*

Which has the greater ratio, $(x^2+y^2)/(x+y)$ or $(x^2-y^2)/(x-y)$, if x and y are positive numbers?

Solution by Harold Sogin, Student, Tilden Tech, H. S., Chicago, Ill.

$$(x^2-y^2)/(x-y) > (x^2+y^2)/(x+y).$$

For if $(x^2+y^2)/(x+y) > (x^2-y^2)/(x-y)$

Then $(x^2+y^2)/(x+y) > (x+y)$ or

$$x^2+y^2 > x^2+2xy+y^2$$

and $$0 > 2xy$$

which is impossible since x and y are positive.

Solutions were also offered by Charles W. Trigg, Los Angeles, Isadore Chertoff, Bayonne, N. J., A. R. Haynes, Tacoma, Wash., and the proposer.

1479. Find two simple fractions, whose denominators are 5 and 9, and whose sum is 2 23/45.

Solution by Isadore Chertoff, Bayonne, N. J.

Let x and y be the numerators of the fractions.

Then $\frac{x}{5}+\frac{y}{9}=\frac{113}{45}$ where x and y must be positive integers.

$$9x+5y=113$$

$$y=\frac{113-9x}{5}=22-2x+\frac{3+x}{5}.\ \text{Let } \frac{3+x}{5}=m,\ m \text{ an integer.}$$

$\therefore\ x=5m-3$ and $y=28-9m$.
Then, for $m=1$, $x=2$, $y=19$.
$m=2$, $x=7$, $y=10$.
$m=3$, $x=12$, $y=1$.

Therefore, the fractions are: $\frac{2}{5}$ and $\frac{19}{9}$, $\frac{7}{5}$ and $\frac{10}{9}$, $\frac{12}{5}$ and $\frac{1}{9}$.

Solutions were also offered by Herman O. Maskey, Fort Wayne, Ind., Margaret Joseph, Milwaukee, Wis., Charles W. Trigg, Los Angeles, W. R. Smith, Lewis Institute, Chicago, and Hyman Marcus, New York City.

1480. *Proposed by J. C. Hall, Butte, Montana.*

Solve, for x, y, and z:

$$x^2+y^2+xy=19 \tag{1}$$
$$x^2+z^2+xz=13 \tag{2}$$
$$y^2+z^2+yz=7 \tag{3}$$

Solution by Charles W. Trigg, Cumnock College, Los Angeles.

Number the equations in the order given. Then

(1)−(2) $$(y-z)(y+z+x)=6. \tag{4}$$

(2)−(3) $$(x+y)(y+x+z)=6. \tag{5}$$

(4)÷(5) and solve $$y=\frac{x+z}{2}.$$

substituting this value in (1) and (3),

$$7x^2+4xz+z^2=76. \tag{6}$$
$$x^2+4xz+7z^2=28. \tag{7}$$

Eliminating the constant terms, and factoring,

$$6(5x+7z)(x-3z)=0.$$

Solving each of these resulting linear equation with (2),

$$x=\pm\frac{7}{3}\sqrt{3}, \qquad x=\pm 3,$$

$$y=\pm\frac{1}{3}\sqrt{3}, \qquad y=\pm 2,$$

$$z=\mp\frac{5}{3}\sqrt{3} \qquad z=\pm 1.$$

Solutions were also offered by Edwin W. Bailey, Delta, Pa., Isadore Chertoff, Bayonne, N. J., A. R. Haynes, Tacoma, Wash., Herman O. Makey, Fort Wayne, Indiana, Julius Freilich, Brooklyn, M. C. Bergen, Chicago, Hyman Marcus, New York City, and Margaret Joseph, Milwaukee, Wis.

1481. *Proposed by A. R. Haynes, Tacoma, Washington.*

If $a=\sin 5°$, $b=\sin 49°$, and $c=\sin 87°$, show that

$$\sin 73° = \frac{a^2-b^2+ac}{4a(a^2-b^2+ac)-(a-b+c)}.$$

Solution by the Proposer.

Let $a^2-b^2+ac=A$. By substitution, from given conditions.

$$A=\sin^2 5-\sin^2 49+\sin 5 \sin 87. \tag{1}$$

From trigonometry, $\sin 2x \sin 2y=\sin^2 (x+y)-\sin^2 (x-y)$. Hence,

$$\sin 5 \sin 87=\sin^2 46-\sin^2 41. \tag{2}$$

By substitution of (2) in (1), and observing that $\sin 49=\cos 41$

$$\begin{aligned} A &= \sin^2 5+\sin^2 46-(\sin^2 49+\sin^2 41) \\ &= \sin^2 5+\sin^2 46-1 \\ &= \sin^2 5-\cos^2 46, \text{ since } \sin^2 46+\cos^2 46=1. \end{aligned} \tag{3}$$

Using relation: $\cos (x+y) \cos (x-y)=\cos^2 x-\sin^2 y$, in (3)

$$A=-\cos 41 \cos 51. \tag{4}$$

Let $a-b+c=B$. To evaluate B, recall that

$$\sin x+\sin y=2 \sin \frac{x+y}{2} \cos \frac{(x-y)}{2}.$$

Then

$$\begin{aligned} B &= \sin 5+\sin 87-\sin 49 \\ &= 2 \sin 46 \cos 41-\sin 49 \\ &= 2 \sin 46 \cos 41-\cos 41 \\ &= (2 \sin 46-1) \cos 41. \end{aligned} \tag{5}$$

Substituting (4) and (5) in the original equation to be established, we have to show

$$\begin{aligned} \sin 73 &= \frac{(-\cos 41) \cos 51}{4 \sin 5(-\cos 41) \cos 51+(-\cos 41)(2 \sin 46-1)} \\ &= \frac{\cos 51}{4 \sin 5 \cos 51+2 \sin 46-1}. \end{aligned} \tag{6}$$

Now

$$\begin{aligned} 2 \sin x \cos y &= \sin (x+y)+\sin (x-y) \\ \therefore \quad 4 \sin 5 \cos 51 &= 2 \sin 56+2 \sin (-46) \\ &= 2 \sin 56-2 \sin 46. \end{aligned} \tag{7}$$

Substitute (7) in (6)

$$\sin 73=\frac{\cos 51}{2 \sin 56-1}. \tag{8}$$

Hence,

$$2 \sin 73 \sin 56-\sin 73=\cos 51$$

or,

$$\sin 73=2 \sin 73 \sin 56-\cos 51 \tag{9}$$

Now

$$2 \sin x \sin y=\cos (x-y)-\cos (x+y)$$

$\therefore$

$$\begin{aligned} 2 \sin 73 \sin 56 &= \cos 17-\cos 129 \\ &= \cos 17+\cos 51. \end{aligned} \tag{10}$$

Substituting (10) in (9) and remembering,

$$\cos 17 = \sin 73$$

equation (9) reduces to the identity:

$$\sin 73 = \sin 73.$$

A solution was also offered by Hyman Marcus, N. Y. C.

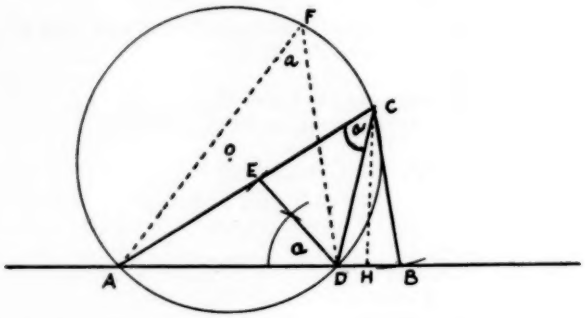
1482. *Proposed by W. W. Taylor, Port Arthur, Texas.*

Construct a triangle, give the difference of the segments of the base into which it is divided by the foot of the aititude, the difference of the base angles, and the ratio of the other two sides.

First Solution

By Aaron Buchman, Buffalo, N. Y.

Let $\angle a$ and segment d be the given difference and let $m:n$ be the given ratio.



Construct circle 0 with chord $AD=d$ and $\angle AFD=\angle a$.

Construct $\angle ADE=\angle a$, and construct DE so that $\frac{m}{n}\ \frac{AD}{DE}$.

Extend AE to cut circle 0 at C. Draw CD.
With C as center and CD as radius cut AD again at B.
Triangle ABC is the required triangle.

Proof

If CH is the altitude, it is easily shown for all cases, that $AH-BH=AD=d$.
Also $\angle CBA-\angle CAB=\angle CDB-CAB=\angle ACD=\angle a$.
It is easily shown that $\Delta AED\sim\Delta ACD$

and $\frac{AC}{CB}=\frac{AC}{CD}=\frac{AD}{ED}=\frac{m}{n}$

Note: If we construct ED so that $\frac{m}{n}=\frac{AD}{DE}$ we do not get a new figure but the above figure reversed.

Second Solution

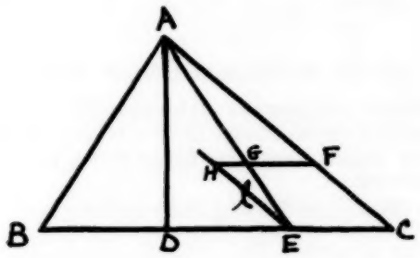
By James A. Lemon, Eaton, Ohio.

Given: $p-q$, the difference of the projections of the sides b and c on the base a;

$B-C$, the difference of the base angles; and
$b:c=m$, the ratio of the sides b and c.

Required: To construct triangle ABC.

Construction:



1. Construct $\angle EAC=B-C$.
2. Mark off segment AF on AC and AG on AE so that $AF:AG=m$.
3. Extend FG to H such that $FH=p-q$.
4. Construct line l through H parallel to AC.
5. The intersection of l and AE is point E.
6. Construct CE through E parallel to FG.

Note: E is not a fixed point until step 5, and C is not fixed until step 6.

7. $CE=FH$.
8. Drop $a\perp AD$ from A to CE extended.
9. Mark off DB on the opposite side of D from E such that $DB=DE$.
10. Draw AB.
11. ABC is the required triangle.
12. If ABC is isosceles, so that $b=c$, it cannot be constructed.

Solutions were also offered by Isadore Chertoff, Bayonne, N. J., A. R. Haynes, Tacoma, Wash., Julius Freilich, Brooklyn, Hyman Marcus, N. Y. C., and the proposer.

1483. *Proposed by Cecil B. Read, Wichita, Kansas.*

Find without use of calculus the maximum value of $a\cos x+b\sin x$.

Solution by Samuel Schwartzberg, Brooklyn.

Let

$$=a\cos x+b\sin x.$$

Then,

$$\frac{y}{\sqrt{a^2+b^2}}=\frac{a\cos x}{\sqrt{a^2+b^2}}+\frac{b\sin x}{\sqrt{a^2+b^2}}. \tag{1}$$

Let

$$\sin t=\frac{a}{\sqrt{a^2+b^2}}, \qquad \cos t=\frac{b}{\sqrt{a^2+b^2}}.$$

Substituting these into (1), we obtain

$$\frac{y}{\sqrt{a^2+b^2}}=\sin(t+x),$$

or

$$y=\sqrt{a^2+b^2}\sin(t+x).$$

From this it is evident that the maximum value of y is $\sqrt{a^2+b^2}$ since the maximum value of $\sin(t+x)$ is 1.

Solutions were also offered by Aaron Buchman, Buffalo, N. Y., J. S. Urban, Cameron, Mo., Hyman Marcus, New York City, Julius Freilich, Brooklyn, N. Y., Isadore Chertoff, Bayonne, N. J., and the proposer.

HIGH SCHOOL HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

1478. Bert Fowler, Centralia, Ill., John R. Whyte, Upper Canada (Toronto) College, Mary Meece, Monticello (Ill.) Community H. S., Emery Gergely, East Technical High School, Cleveland.

1479. Emery Gergely, Harold H. Sogin, Tilden Tech. H. S. Chicago, John R. Whyte.

1482. John R. Whyte.

PROBLEMS FOR SOLUTION

1496. *Proposed by A. R. Haynes, Tacoma, Wash.*

Prove (without using the radical values of the functions):

$$\frac{1}{1+\sin 15^\circ-\cos 15^\circ}=\frac{1}{\sin 30^\circ}+\frac{1}{\sin 45^\circ}.$$

1497. *Proposed by Aaron Buchman, Buffalo, N. Y.*

Given isosceles triangle ABC with base AC extended through C to any point D. On segment BD, a point, E, is taken such that $\angle BAE=\angle BDA$. FE is perpendicular to BD and meets AD in F. Prove that $AF:FC=AE:EC$.

1498. *Proposed by C. R. Green, Winnipeg, Canada.*

PQ and XY are two walls at right angles to QY. MY and NQ are two ladders, MY being 40 feet long and NQ 30 feet long. If the ladders meet at A, which is 15 feet above QY, find the length of QY.

1499. *Proposed by Cecil B. Read, Wichita, Kansas.*

Given two circles intersecting at A, to draw through A, a secant ABC, intersecting the circles at B and C, such that a given length shall be a mean proportional between AB and AC.

1500. *Proposed by Norman Anning, University of Michigan.*

Suggestion: It is well known that every binomial coefficient except 1 is expressible as the sum of two binomial coefficients. Prove that every trinomial coefficient

$$\frac{(p+q+r)!}{p!q!r!} \quad \text{where} \quad p>0,\ q>0,\ r>0.$$

is expressible as the sum of three trinomial coefficients.

1501. *Proposed by C. T. Adams, New Orleans.*

In a triangle ABC, F and E are variable points on AB and AC respectively. If $\frac{AF}{FB}+\frac{AE}{EC}$ is constant, find the locus, 0, of intersection of BE and CF. Show that the area BOC is constant.

SCIENCE QUESTIONS

April, 1937

Conducted by Franklin T. Jones

(Send all communications to Franklin T. Jones, 10109 Wilbur Avenue, S. E. Cleveland, Ohio.)

This department is a forum for discussing Tests, Experiments, Pedagogical Questions, Scientific Happenings, Practical Applications of Scientific Principles, Popular Beliefs and Misapprehensions concerning Scientific Matters, Newspaper Science, Think Problems (mostly scientific), Trick Questions, Borderline Science Questions involving Mathematical Treatment, College Entrance Examination Questions and Problems, Any Problem or Question that will help teachers to make Science Teaching interesting.

The discussion usually takes the Question and Answer Form. Readers, whether teachers and students or outside school walls, are invited to propose Questions or Problems and to answer Problems and Questions proposed by others.

As a Mode of Recognizing contributors, the Guild of Question Raisers and Answerers (GQRA) has been formed and more than 170 contributors have already been admitted to Membership. Classes or individuals may become members by proposing a question or submitting an answer.

JOIN THE GQRA

NEW MEMBERS GQRA, APRIL, 1937

171. J. S. Urban, Cameron, Missouri.
172. Robert E. McKay, Middleport High School, Middleport, Ohio.

QUIZ OF THE MONTH

791. *Clay Herrick, Jr. (GQRA, No. 90) read Midweek Pictorial and rewrites one of their problems as follows:*

"It is reported that J. Alexander Bott wired the home office of The Earthworm Tractor Co. 'SEND MORE MONEY.' After due consideration the Sales Manager arranged the telegram like this

$$\begin{array}{r} \text{SEND} \\ \text{MORE} \\ \hline \text{MONEY} \end{array}$$

assigned figures to each letter and wired him $106.52."

How did he arrive at this figure and is it correct?

(*Where did Midweek pick up the problem? Let's run it down if possible.*)

The title "Quiz of the Month" is following along the line suggested by

Louis T. Masson (GQRA, No. 52) in the March issue of SCHOOL SCIENCE AND MATHEMATICS.

If we get a good one, we will publish it every month under this or some better title that *our readers* may suggest. *Who will be quiz for May and June, etc.?*

SOCIAL SCIENCE

792. *From program of the SPRING RALLY AND OUTING of Science and Mathematics Teachers at Western Reserve Academy, Hudson, Ohio, March 13, 1937.*

"What can the teacher of Social Science draw from the Field of Science and Mathematics?"

Discussed by Dr. Charles E. Gehlke, School of Social Sciences, Western Reserve University.

MAKE THE RIGHT CONNECTIONS

793. *Proposed by J. S. Urban (Elected to GQRA, No. 171), Cameron, Missouri.*

In my high school Physics course I use an adaptation of Experiment 48, in Krenerick's "Manual of Experiments and Projects in High School Physics." This is the familiar experiment for measuring resistance by the ammeter-voltmeter method except that he suggests a volt-ammeter instead of separate instruments. I use Cenco, three-button galvanometers with appropriate shunts. To save time we wish to connect galvanometer, battery and resistance to a double-throw, double-pole switch so that throwing the switch one way gives a voltmeter connected in parallel with the resistance and throwing the switch the other way gives an ammeter in series with the resistance. How can it be done?

Maybe the above problem is too trivial for publication in "Science Questions," but I have never seen it in any book and it is a little hard to get the right slant on it.

FREAKISH QUESTIONS

794. *Proposed by Robert E. McKay (Elected to GQRA, No. 172), Middleport High School, Middleport, Ohio.*

Science teachers are quite often asked to settle an argument on some scientific question, or to explain some "freakish" phenomena on the basis of scientific laws. Recently I was approached by a man with one of these so called "freakish" problems. I had to stop and think for a few minutes before I could give a suitable explanation. Perhaps some of the readers would like to bring it before their physics classes.

On one very cold evening this winter this man had taken two bottles of pop from his kitchen window where they had been for a number of days. One bottle had frozen solid. The other was a liquid, so he decided to drink it. He uncapped it and raised it to his mouth, but as he did so, the contents became a solid mass.

Explain that!

CORRECT USE OF FOOT-POUND

737. *Comment by W. F. Roecker (GQRA, No. 15).*

I was especially pleased about the response of Norman S. Greiner, Somerville, N. J. on 737 "What is a Foot-Pound?" in the November issue. I believe every teacher on this subject should teach the foot-pound with this viewpoint as stated so clearly by Mr. Greiner.

Mr. Greiner said: (Norman S. Greiner (GQRA, No. 21), Somerville, N. J.) I believe the definition that satisfies all cases is—"A ft.-lb. is the work done when a *force* of one pound acts through a distance of one foot." (See November issue, page 921.)

WHETHER OUR SCIENCE COURSES ARE AFFECTING OUR STUDENTS IN PRACTICAL WAYS

790. *A Continuation of This Title from February, 1937, and March, 1937). Tests—Proposed by Collis M. Bardin, Washington Union High School, Fresno, California (GQRA No. 158).*

I enclose a set of questions for your GQRA in SCHOOL SCIENCE AND MATHEMATICS which may be of interest. This is the present form of a set which I have been slowly developing for some time and have used at the beginning and the end of the year in an attempt to learn "*whether our science courses are affecting students in practical ways.*"

The selection of questions is neither complete nor well-balanced as yet. Nor are there any "conclusions" of great interest. I have, however, found the results interesting and helpful in improving our instruction. It should be noted, of course, that the emphasis in that instruction is on understanding of principles and that the specific applications used in the test are in no way emphasized because of their occurrence there.

I recognize the limitations of your space, and if I were to select a few of the questions as having been most interesting as to results, I would suggest: 8, 15, 16, 17, 19, 37, 68, 71, 73, 75, 76, 80, 83, 85, 89. Stars are placed opposite these numbers in the lists that follow.

Name_____ 9/36 Page 7

122. An *acid* burn should be *treated* first with large quantities of water, followed by a solution of baking soda.
123. *Cooking* involves chemical changes, therefore it increases the rate of destruction of *vitamins* that are sensitive to heat.
124. Gasoline containing some "*ethyl*" may be used in gasoline stoves.
125. Gasoline containing some "*ethyl*" may be used for cleaning.
126. Gasoline containing some "*ethyl*" should not be allowed to come into contact with the skin.
127. Gasoline containing some "*ethyl*" removes carbon.
128. Gasoline containing some "*ethyl*" should be used in all cars.
129. *Every* balanced *diet* should *include* some leafy vegetables, some grain food, some fruit, some dairy product, some meat, some irradiated food or extra source of vitamin D, some extra bran as roughage, some yeast.
130. Nothing should be *habitually* taken for *headaches* without the advice of a physician.
131. For headaches, *aspirin* is never harmful.
132. Headache preparations containing *acetanilide* or *phenacetin* (indicated on the label) are potentially dangerous.
133. *Amidopyrine*, present in many headache preparations but not required to be stated on the label, is seriously dangerous to a few susceptible individuals.
134. *Smoke* is a sign of waste.
135. Washing soda should be thoroughly dissolved before use in *laundering*.

136. High concentrations of "*Clorox*" or exposure for long periods would weaken fabrics.
137. *A solution of carbon dioxide attacks marble.* Therefore soda water must have an ill effect on the lining of the *stomach.*
138. Motors should be stopped while *filling gas* tanks.
139. *Cars* should never be operated with *all windows* and *ventilators* closed.
140. No *gasoline* saving gadget or dope is *economical.*
141. *Bottled fuels,* like "Shellane" should be single substances, not mixtures.
142. *Pasteurizing* milk spoils an important source of vitamin C.
143. *Vitamins* are minerals.
144. In a *reducing diet* no class of foods should be entirely *eliminated.*
145. *Pasteurized milk,* needs to be *handled* just as carefully, especially after pasteurizing, as raw milk.
146. Tuberculin testing is an adequate substitute for pasteurization in *safeguarding the milk supply.*
147. *Starches* and *proteins* should not be eaten together.
148. The best present safeguard against *cancer* is prompt medical attention.
149. After opening, *canned milk* should be treated the same as ordinary milk.
150. Non-acid, not-syruped, *canned food,* especially if home canned, which gives any indication of spoilage, should not even be tasted.
151. *Fats* which melt below body temperature are more readily digestible.
152. *Hydrogenation* of oils improves their digestibility.
153. It is preferable that *canned foods* be removed from the can on opening.
154. Careful design of the refrigerating unit is at present a more important *safety consideration* than the choice of any non-toxic (so-called) refrigerant.
155. *Aluminum cooking* utensils in common use yield sufficient aluminum in the food to endanger health.
156. Acid foods should not be *stored* in aluminum containers.
157. A silver spoon in gelatin in an aluminum dish *is a bad* combination.
158. Some *baking powders* are serious *health* menaces.
159. *Oleomargarine* can safely be used as an economical substitute for butter provided the missing vitamins are otherwise secured.
160. Meat containing *sulphites* is undesirable.
161. *Philippine* mahogany is not mahogany.
162. *Lastex* makes good stocking tops.
163. *Floating soaps* are purer than non-floating.
165. *Soap* should contain no free alkali.
166. *Sediment* in milk is a sign of carelessness.
167. Care should be taken to use a *can-opener* which produces a minimum of metal fragments.
168. Exposure to the *vapor* of wood alcohol is dangerous.
169. Boric acid may be used on floors for *dancing.*
170. After cleaning *copper with vinegar,* it should be very thoroughly washed to remove poisonous substances formed.
171. *Mosquitoes* may be practically eliminated by covering with a film of oil at proper times all stagnant water within a radius of about a mile.
172. Fine whiting is the hardest *abrasive* that should be used in polishing soft metals like *silver* and *chromium.*
173. Apples are the only fruits on which *spray residues* are dangerous.
174. *Iodine* should not be applied and tightly covered.

175. A *supercharger* increases the efficiency of a gasoline engine.
176. Astringent solutions containing as little as *1% carbolic acid* may cause severe skin irritation.
177. Baby powders should contain *zinc stearate.*
178. The application of *glycerin* or lotions containing glycerin makes the skin more moist.
179. *Alcohol* applied after shaving prevents enlarged pores.
180. No known substance *stimulates* the growth of hair.
181. No known substance will make gray hair grow out its *previous* color.
182. No known substance will safely and permanently *prevent* the *growth* of hair.
183. Use of *thyroid* for reducing except under the care of a physician is dangerous.
184. Use of thyroid for *reducing* is usually undesirable.
185. Reducing preparations which contain *thyroid* must so state on the label.
186. *Dinitrophenol* is too dangerous for use in reducing at present.
187. *Castile* soap, as sold in the U. S., is usually better than other soaps.

"PROBLEM NO. TWO"

764. *Proposed by Charles C. D'Amico (GQRA No. 49), Albion High School, Albion, N. Y. ("Problem No. 1" was proposed by Mr. D'Amico, as No. 681.) Here is "Number Two."*

A battery of twelve equal cells, in series, screwed up in a box, being suspected of having some of the cells wrongly connected, is put into a circuit with a galvanometer and two cells similar to the others. Currents in the ratio of 3 to 2 are obtained according as the introduced cells are arranged, so as to work with or against the battery. What is the state of the battery? Give reasons for your answer.

Solution by Charles W. Trigg (GQRA No. 20), Cumnock College, Los Angeles.

Since the cells in the battery and the introduced cells have the same voltage and resistance and are connected in series, the resistance of the circuit is the same regardless of the number of reversals in connection. Hence, $I_1:I_2::E_1:E_1::3:2$. Let k be the E.M.F. of one of the equal cells and x the number of cells reversed in the battery and whose E.M.F. thus opposes that of the remaining $(12-x)$ cells. Then $k(12-x+2-x):k(12-x-2-x)::3:2$. Solving, $x=1$. Therefore in the battery, one of the cells is so connected as to oppose the other eleven.

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Silken ladies of fiction may glide across rayon pages in tomorrow's novels. At any rate, a Czech chemist has produced a synthetic fabric of the rayon type, suitable for printing purposes. It is stated to be very durable, and to cost less than really good book paper.

BOOKS RECEIVED

Plane and Spherical Trigonometry, by Joseph B. Rosenbach, Professor of Mathematics; Edwin A. Whitman, Associate Professor of Mathematics; and David Moskovitz, Assistant Professor of Mathematics, The Carnegie Institute of Technology. Cloth. Pages x+336+xxvii. 13.5×21 cm. 1937. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $2.00.

Plane Trigonometry, by Joseph B. Rosenbach, Professor of Mathematics; Edwin A. Whitman, Associate Professor of Mathematics; and David Moskovitz, Assistant Professor of Mathematics, The Carnegie Institute of Technology. Cloth. Pages x+288+xxiii. 13.5×21 cm. 1937. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $1.80.

Plane Trigonometry, by K. B. Patterson and A. O. Hickson, Duke University. Cloth. Pages ix+219. 13×20 cm. 1936. F. S. Crofts and Company, 41 Union Square, West, New York, N. Y. Price $1.75.

Mammalian Anatomy with Special Reference to the Cat, by Alvin Davison, Ex-Fellow of Princeton University; Professor of Biology in Lafayette College and revised by Frank A. Stromsten, Associate Professor of Animal Biology, State University of Iowa. Sixth Edition. Cloth. Pages xiv+328. 14×21.5 cm. 1937. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price $3.00.

The Insect Man, by Eleanor Doorly. Cloth. Pages xvii+180. 13×20 cm. 1937. D. Appleton-Century Company, 35 West 32nd Street, New York, N. Y. Price $1.50.

Analytic Geometry and Calculus, by Bolling H. Crenshaw, Late Head of Department of Mathematics, Alabama Polytechnic Institute, and Cincinnatus D. Killebrew, Late Professor of Mathematics, Alabama Polytechnic Institute. Second Edition revised by Ralph D. Doner, Professor of Mathematics, Alabama Polytechnic Institute. Cloth. Pages xii+222. 15×23 cm. 1937. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price $2.75.

A Laboratory Guide to the Study of Qualitative Analysis, by E. H. S. Bailey, Late Professor of Chemistry in the University of Kansas, and Hamilton P. Cady, Professor of Chemistry in the University of Kansas. Tenth Edition revised by Arthur W. Davidson, Associate Professor of Chemistry in the University of Kansas in Collaboration with the Junior Author. Cloth. Pages xiii+322. 14×21.5 cm. 1937. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price $2.00.

Culture Methods for Invertebrate Animals, by Paul S. Galtsoff, Frank E. Lutz, Paul S. Welch, James G. Needham, Chairman, assisted by many specialists whose names appear in connection with their respective contributions to this volume. Cloth. Pages xxxii+590. 15×23 cm. 1937. Comstock Publishing Company, 124 Roberts Place, Ithaca, N. Y. Price $4.00.

Laboratory Methods of Organic Chemistry, by L. Gattermann, and completely revised by Heinrich Wieland. Translated from the twenty-fourth German Edition, by W. McCartney, Late Assistant in the Department of Medical Chemistry, University of Edinburgh. Cloth. Pages xvi+435. 14.5×22 cm. 1935. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $4.50.

Chemistry Tests Forms, A and B, by Kenneth E. Conn, Head of Chemistry Department, High School, Bloomington, Indiana, and Herman T. Briscoe, Professor of Chemistry, Indiana University, Bloomington, Indiana. For Use by Teachers Only. Form A, 60 pages. Form B, 61 pages. Paper. 19×25.5 cm. 1936. Mentzer, Bush and Company, 2210 South Park Way, Chicago, Ill.

A Combined Laboratory Manual and Workbook in Physics, by S. G.

Cook, Head of the Physics Department, High School, East St. Louis, Illinois, and Ira C. Davis, Assistant Professor in the Teaching of Science, University of Wisconsin, Madison, Wis. Paper. 238 pages. 19×25.5 cm. 1936. Mentzer, Bush and Company, 2210 South Park Way, Chicago, Ill.

BOOK REVIEWS

Recent Advances in Physical Chemistry, by Samuel Glasstone, Ph.D., D.Sc. (Lond.), F.I.C., Lecturer in Physical Chemistry at the University of Sheffield. Third Edition. Pages viii plus 477. 2.75×15×20.5 cm. 31 Illustrations. Cloth. 1936. Blakiston. $5.00.

To those who know the previous editions of this text it may be said that the most noteworthy addition of new material is a "long section on the application of quantum mechanics to problems of valency and molecular structure, including an account of the important phenomenon which has become generally known under the name of 'resonance.'" As far as it has been possible to do so the author has made his treatment of these topics non-mathematical giving the physical and chemical significance of the conclusions arrived at by others who use wave mechanics. The chapter on "Acid-Base and Salt Catalysis" which the 2nd edition contained has been omitted and may be found in revised form in a new companion volume (Recent Advances in General Chemistry. See following book review.) For those who are unfamiliar with the previous editions we may add that the text was originally designed to provide for those students (and teachers) who do not have access to current literature or time to use it if available a condensed account of the more important advances in the field of physical chemistry. The chapters cover "The Electronic Theory of Valence," "The Parachor," "Dipole Moments," "Molecular Spectra," "Homogeneous Gas Reactions," "Photochemical Reactions,""The Properties of Surfaces," "Heterogeneous Catalysis," and "Strong Electrolytes," Many references follow each chapter so that the earnest student may follow up and go more deeply into any topic that especially interests him. A brief study of some of the topics shows that the teaching method is excellent.

FRANK B. WADE

Recent Advances in General Chemistry, by Samuel Glasstone, Ph.D., D.Sc. (Lond.), F.I.C. Lecturer in Physical Chemistry at the University of Sheffield, First Edition. Pages ix plus 430. 2.5×15×20.5 cm. 25 Illustrations. Cloth. 1936. Blakiston. $5.00.

This new text is intended to be a companion to the author's similar text on Physical Chemistry and it will be most useful to students and teachers who want to keep themselves up in regard to modern trends and advances in general chemistry. The author has condensed the literature and made it acceptable to the reader. To this end it has been made as non-mathematical as possible. The subjects covered include "Atomic Disintegration," "Statistical Methods," "Ortho and Para Hydrogen," "Deuterium and Its Compounds," "Electron Diffraction by Gases and Vapors," "Solubility," "The Mechanisms of Reactions in Solution," "Acid-Base and Salt Catalysis" and "Simple Organic Free Radicals." A brief study of the chapter on Acid-Base and Salt Catalysis shows that the author is a good teacher. The complexities of the situation are well brought out and the student should gather that "it is not nature but man that is simple."

FRANK B. WADE

An Elementary Survey of Modern Physics, by Gordon Ferrie Hull, Professor of Physics, Dartmouth College. Cloth. Pages xxiv+457. 13.5×21.5 cm. 1936. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $4.50.

The purpose of this book is "to furnish material for a second-year course" in college physics. It is presented as an elementary survey stressing the experimental viewpoint. Nearly every page calls attention to the results of experimental work. When use is made of an experiment the fundamental steps are briefly given, the results enumerated, and the conclusions or implications stated; details of the experiment and theoretical developments are omitted or given in the appendix. In this sense the book is elementary. However, many students will not be satisfied without making consistent use of the appendix and of references where details and theory are wanted.

The author has in most cases made a happy selection of analogies in presenting difficult topics. His comparison of an electron expelled from a radioactive atom to a rifle bullet on page 4 is an early example. The book is filled with similar cases. Clear reasoning is constantly in evidence. In a few cases the drawings are faulty and show a lack of coordination between author and artist. Some of the graphs and drawings are produced without adequate legends making it necessary to read the descriptions to get the meaning that should be instantly shown by the illustrations. But these are minor points. The book is of a very high degree of excellence throughout, accurate in description and narration, clear and concise in explanation, scientific in interpretation. It brings the story of modern physics down to the date of publication and supplies a text worthy of consideration whereever courses in modern physics are given.

G. W. W.

Heat for Advanced Students, by The Late Edwin Edser, Fellow of the Physical Society of London, and Revised by N. M. Bligh, Fellow of the Physical Society of London. Cloth. Pages x+487. 11.5×17.5 cm. 1936. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.75.

The original edition of this text appeared in 1899. Since then it has been reprinted many times with minor changes and has been widely used. The present edition shows a number of changes, including the addition of some paragraphs, especially in the chapter on radiation, elimination of some obsolete matter, changes in several of the illustrations, and discussion of new experiments. The major improvement consists in the introduction of the calculus for theoretical sections especially in thermodynamics. The index in the revised edition is separated into two parts, a name index and a subject index.

The general form of the former editions has been retained and the apparent change is so little that a cursory examination leaves the impression that no important changes have been made. This is not, however, the case but it is regrettable that a more complete modernization of the text, both in form and content was not deemed necessary by the publishers. In spite of this the text will no doubt hold its well-earned place as a favorite text for special courses in heat and as a valuable reference.

G. W. W.

On Jungle Trails, by Frank Buck, Author of *Bring 'em Back Alive*. Cloth. Pages vii+280. 12×20 cm. 1936. World Book Company, Yonkers-on-Hudson, New York, N. Y. Price 96 cents.

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G. W. W.

Outlines of General Zoology, by Horatio Hackett Newman, Professor of Zoology in the University of Chicago. Third Edition. Cloth. Pages xxvii +661. 14×21.5 cm. 1936. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.50.

This new edition of Newman's successful textbook is larger and better than its predecessors. It follows the same general plan as the previous editions, in that it is an expression of the author's conviction that the best method of teaching zoology is a compromise between the type-study method and the principles method.

From his experiences at the University of Chicago Professor Newman has become convinced that the general survey courses have come to stay; therefore he has kept in mind such courses, as well as the laboratory course, while writing the present edition.

The discussion of principles occupies somewhat more than half the space. The first 160 pages are devoted to general matters, such as the history of biology, the cosmic setting, the cell, protoplasm, and classification. Then comes a description of representative animal types from the nine most commonly studied phyla of invertebrates and the chordates—275 pages. The invertebrates are considered in phylogenetic order, beginning with the Protozoa. The concluding 170 pages deal with biological mechanisms, individual as well as racial, including general principles of physiological processes, special adaptations, evolution, and genetics.

A new feature in this edition is a brief summary at the end of most of the chapters. The book is larger by 120 pages than the second edition, most of the increase being in the section on principles, although a new introductory chapter on the chordates has been added.

With his easy flowing style and his understanding of students' interests, the author has produced a most readable and attractive book.

A bibliography—consisting chiefly of book and monograph titles—which he considers a fairly comprehensive working library for a teacher of general zoology, is appended. There is a glossary of thirty-three pages and an adequate index.

EDWARD C. COLIN

Social Biology. A Textbook for Secondary Schools, by Everett P. Walton, A.B. and Philip E. Foss, A.M. of the biology department, Hartford Public High School, Hartford, Conn. Washable cloth. 14×19 cm. xv +572 pages, with 360 illustrations. 1936. Published by P. Blakiston's Son and Co., Inc. Philadelphia. Price $1.68.

This book has many excellent features. The first is, that it is a real social biology. Not just a name. The social relations of plants and animals with each other and man are given much attention. Another important point in its favor is that the two divisions of biology, plants and animals, are given fair treatment, as one great topic, not, as often is the case, as small separate texts of botany and zoology unrelated.

QUALITATIVE ANALYSIS of Science Textbooks

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Another good feature is the inclusion of portraits of special students of particular fields, as for example Frank M. Chapman in the chapter on birds and Raymond Ditmar in the chapter on reptiles, and many more of equal importance throughout the book. At the close of the chapters there are not only the usual review questions found in most texts, but also a list of "interesting projects," and a list of important words to be defined, but in addition, with many chapters a "*self-testing Exercise*" for the student of important characters to be remembered. The illustrations are numerous and excellent for reenforcing the topic under discussion. At the end of the book is a list of well chosen books the pupils should read.

This is an exceptionally good book, and we think it should be widely used in secondary schools.

W. WHITNEY

General Science for Today, by Ralph K. Watkins, Ph.D., Professor of Education, Univ. of Missouri, and Ralph C. Bedell, Ph.D., Professor of Education, State Teachers College, Kirksville, Missouri.

General Science for Today is a revised edition of the book of the same title published by Watkins and Bedell in 1933.

The authors have expanded and simplified some portions of the first edition. They have attempted as stated in the Preface to the revised edition, "to present a continuous, uninterrupted story of science as it has affected mankind on the earth."

The material has been divided into three general divisions; the first deals with the earth and its inhabitants or man's environment, the second deals with the substances found on and in the earth and the natural forces, showing the ways in which man makes use of them. The third section treats of man's attempt to control the forces of the earth, including the forces operating within his own body.

Emphasis is placed upon the solutions of science problems. The authors wish to help students build up better understanding of large ideas in science through their application to familiar things, and to enable the students to solve the scientific problems which they will encounter in life situations.

Before each unit is a short review of "what you may expect to find in this Unit," followed by a page of questions headed, "Problems This Unit Will Help You Solve." This should cause the pupils to approach this subject in a problem-solving manner. Following each unit is a list of "Facts and Principles You Should Remember," which should test the pupils' knowledge of the Unit just covered.

One criticism of the arrangement of material might be that the authors might well have placed the last unit, "Developing a Scientific Attitude," first in the book. If this were done the pupils would make use of this material while studying the text. Since this Unit deals with such topics as, the difference between superstition and scientific truth, how to attack everyday science problems, what agencies supply reliable scientific information, how to use reliable sources of information in solving personal science problems, et cetera, it would be of greater value to the students if studied at the beginning, rather than at the end, of the course.

H. G. MCMULLEN

Our Natural Resources and Their Conservation, by A. E. Parkins, George Peabody College for Teachers, and J. R. Whitaker, University of Wisconsin as Editors. Cloth. Pages xii+650. 14.5×23 cm. 1936. John Wiley and Sons, Inc., 440 4th Avenue, New York, N. Y. Price $4.00.

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The unusual feature of this book is that each chapter was written by a man who is an authority in his respective field. It contains 635 pages which are divided into twenty-three chapters; an appendix composed of reference maps, agricultural maps, and a bibliography; and an index.

Part I by Wallace W. Atwood of Clark University, relates the development of our present conservation program. The first three chapters of Part II of this book deal with the resources, growth, development, soil formation and conservation of our land areas. The remaining five chapters discuss tree crops, the utilization of our arid and semiarid lands, grass lands, effects of animal life on grasslands, insects, wet and overflow lands and agricultural prospects. These chapters were written by Stephen S. Visher of Indiana University; Louis A. Wolfanger, Columbia University; H. H. Bennett, U. S. Dept. of Agriculture; George Miller, State Teachers College, Mankato, Minnesota; J. Russell Smith, Columbia University; Ralph H. Brown, University of Minnesota; V. E. Shelford, University of Illinois; H. C. Hanson, North Dakota Agricultural College; and O. E. Baker, Senior Agricultural Economist of the U. S. Dept. of Agriculture. Two chapters compose Part III in which our forests are discussed by J. R. Whitaker of the University of Wisconsin. Part IV is devoted to an analysis of our water problems. The aspects of water supply, water power, floods and flood control with reference to conservation are adequately treated by Robert M. Brown, Rhode Island College of Education; Frank Williams, University of Pennsylvania; A. E. Parkins, George Peabody College; and Guy-Harold Smith of Ohio State University. The chapters on minerals and mineral fuels which make up Part V were written by William H. Hass of Northwestern University and Nels A. Bengson of the University of Nebraska. Part VI consists of a chapter by Helen M. Strong of the Soil Conservation Service of the U. S. Department of Agriculture in which she discusses the relation of conservation to manufacturing. Parts VII, VIII and IX discuss problems of wild life conservation, recreational resources and the conservation of man. V. E. Shelford, University of Illinois; Edward C. Prophet, Michigan State Teachers College; and Ellsworth Huntington of Yale University cooperated in the writing of the chapters which compose this section. Part X, composed by Loyal Durand, Jr., University of Wisconsin and George Reaves of Teachers College of Columbia University, is made up of two chapters which deal with the plans and attitude of local, state and national government towards the conservation of natural resources.

The book is profusely illustrated with charts, graphs, natural photographs and maps. The data, comparisons and conclusions by this extraordinary group of authors certainly warrant consideration.

LOWELL C. WARNER

The Microscope, by Simon Henry Gage, Emeritus Professor of Histology and Embryology in Cornell University. Sixteenth Edition, Revised and Enlarged. Cloth. Pages viii+617. 15×23 cm. 1936. Comstock Publishing Company, Inc., 124 Roberts Place, Cornell Heights, Ithaca, N. Y. Price $4.00.

The development of technique and laboratory procedures has more closely linked all branches of science. This relationship has, moreover, created a demand for a knowledge of at least the fundamentals of optics and their applications. The author seems fully aware of this condition and has correlated elementary theory and practical applications of one of our most important optical devices, the microscope. This book is written not only for the expert technician but serves as an authoritative

EVOLUTION,
THE UNFOLDER OF NUMBERS

ADDITION, subtraction, multiplication, division; these are the algebraic operations which are necessary and sufficient to develop a linear universe of numbers.

A one dimensional universe of numbers furnishes a mathematics which is adequate for one dimensional thought. In how many dimensions does a man think? Thought of time is one dimensional; thought of space is three dimensional; simultaneous thought of time and space is four dimensional. Thought of color is three dimensional; add color to time and space and then thought becomes seven dimensional. Thought of sound is x dimensional. Determine x for yourself; you will find some difficulties. Thought of time, space, color and sound is $7+x$ dimensional. And this is not the end. Man thinks in many dimensions. Many dimensional thought requires a many dimensional universe of numbers.

Involution and evolution are reputed to unfold the linear universe of rational numbers into a plane universe of complex numbers. A two dimensional universe of numbers is inadequate to contain $7+x$ dimensions of thought.

It is the reputation, not the power, of involution and evolution which is limited to two dimensions. Evolution, that is, the extraction of roots, unfolds a universe of true, commutative, algebraic numbers of an unlimited number of dimensions. This fact has been an implied part of mathematics since man first extracted a root. The explicit recognition of the fact has been delayed because the symbol of evolution, the radical sign, taken by itself, furnishes only a vague and ambiguous symbolization of the whole truth. The underlying truth only needs clarification by reclothing evolution with an adequate code of symbols.

This is the thesis of two monographs by Robert A. Philip.

MULTIFOLIATE NUMBERS.....Price one dollar

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reference book for the student. The book contains 617 pages and is divided into fifteen chapters, a bibliography of over 200 references, interpolation tables of metric and English units, and a table of natural sines. The first chapter deals with the parts of the simple and compound microscopes such as lenses, objectives, oculars, etc.; also care of the instrument, care of the observer's eyes, technique of microscopic observation, and standards of the Royal Microscopic Society. Chapters two and three take up dark and bright field microscopy, giving conditions for the production of each, illumination and types of light sources, their production and desirability, objectives, condensers, experiments which might be performed, and the probable difficulties and how to overcome them. Chapters four, five and six are devoted to the more recent fields of microscopic study, namely, the developments due to the polarizing microscope, the micro-spectroscope, and the ultra-violet microscope, The polariscope, its uses, experiments and optical principles are discussed in chapter four. The theories of light, its properties, reflection, refraction, dispersion, diffraction, critical angle,index of refraction, etc., as well as types of aberration and lenses, are given ample text and diagrammatic treatment. Chapter five gives a description of the micro-spectroscope, a discussion of the various types of spectra with methods of production and interpretation. The sixth chapter contains a description of the ultra-violet microscope and physical analysis. The author has included in this chapter a discussion of quartz lamps, mercury lamps, filters and their uses and a number of experiments. Chapter seven should prove one of the most valuable to the student and the technician. The whole chapter is devoted to the interpretation of the appearances. The effects of various optical phenomena are explained and remedial suggestions given for defects. The theory and geometry of magnification and micrometry, types of micrometers, and measurements by use of the compound microscope are treated in chapter eight. Chapter nine gives directions for drawing with a microscope by use of the Camera Lucida, projection lantern, and photographic camera. Chapter ten is devoted to microphotography, determination of the scale of photographs, magnification, lighting, equipment, filters, color photography, selection of plates and developing procedures. Chapters eleven and twelve contain suggestions for mounting, labeling, storing, reagents, stains, dyes, sectioning, etc. Chapter thirteen is devoted to technique and procedures for obtaining serial sections of organs, small animals, and embryos. Chapter fourteen discusses micro-incineration and optical appliances for their examination together with methods of preparation and incineration. Chapter fifteen is given over to the history of lenses and microscopes. This includes theories and properties of light, scientists of importance in this field, and development of the various kinds of microscopes and accessories.

The book is written in non-technical language with new terms defined as they are used. At the end of each chapter is a list of references on the topics discussed in that chapter. Other commendable features of the book are the extensive use of graphs, photographs and geometrical diagrams, numerous tables, charts and remedial suggestions.

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BLACK HILLS SCIENCE CLUB

By Clara M. Roberts

The Black Hills Science Club is rather unique in that anyone may belong and there are no dues. A small fee of ten cents is collected at about every other meeting to pay for postal card notices and occasionally for the dinner of one of the speakers, if he comes from a distance.

The membership represents diverse occupations. It boasts of college presidents and professors, geologists, chemists, mining-engineers, professors of teachers colleges, doctors, surgeons, soil-erosion workers, metallurgists, stenographers, insurance agents, high school and grade school teachers, C.C.C. Boys, high school and college students, and superintendents of industries, such as mining, sugar beet, quarrying.

The meeting time is on Saturday. The forenoon activities are in the form of field trips that are related to the more formal program that follows immediately after the noon luncheon.

An article concerning the Black Hills Science Club appeared in your magazine in the spring of 1935. Hence this article will take up with the first fall meeting of 1935. The club met at Pine Creek C. C. Camp on Oct. 5. This camp is located near the foot of Mt. Rushmore. The field trip consisted of visits to various projects carried on by this camp. At the luncheon meeting, R. E. Williams, educational director of the camp, talked on "Educational Work in the C.C.C. Camp."

Captain R. W. Allen, Company Surgeon of the camp, told of "The Founding of the Pine Creek Camp."

Officers for the year were Edward D. Freeland of Wind Cave, President, M. G. Richmond, Vice-President, and Clara M. Roberts, Sec.-Treas.

On March 17, 1936, the club was invited to Fort Meade Army Camp. Guests inspected barracks, hospitals, kitchens, and stables. The main program was held in Riding Hall where guests were shown exhibition riding, machine gun demonstration, methods of communication in War, and army trucks. Major Philips presided. This visit was made possible through the courtesy of Colonel Beck, commanding officer at Fort Meade.

April 4, 1936, the club visited the Homestake Mine. The new power plant at Kirk and the Ross shaft were visited on the field trip. The two speakers on the afternoon program were C. N. Krevig, Assistant Geologist and R. K. Hall, chief metallurgist, both of the Homestake Mining Company. The topics discussed were "The Geological Formation of the Gold Deposits" and "The Process of Extracting Gold from the Ore." Following the program guests were conducted through the stamp mill and Cyanide Plant of the Company.

The Club gathered at Trenton, S. D., on Sept. 26, 1936, to hear Frank L. Hess of the Bureau of Mines Dept. of Interior talk on Pegmatites. Mr. Barnaleus Bryon, Oil Economist, of New York City talked on "Early Days of Oil Exploration in Venezuela." After the program, Mr. Hess led the guests on a field trip to visit the valuable ores and minerals at the Mines in Trenton.

At the Wind Cave Meeting on Dec. 12, 1936, club members were guests of Supt. Edward D. Freeland on a trip through the cave. The afternoon program consisted of two talks. Lt. Earl A. Madsen talked on the "Responsibility of the Army in Connection with the C.C.C.'s." Superintendent Edward Freeland told of the educational features of the C.C.C. Program and of the work of the C.C.C.'s in the improvement of the Cave. Officers for the coming year were elected. Mr. M. G. Richmond of Spearfish, President, Mr. V. Calvin McKim of Chadron, Neb., Vice-President, and Clara M. Roberts of Rapid City, Sec.-Treas.

The last meeting was held at Rapid City, Jan. 16, 1937. On a field trip the Sewage Disposal Plant and the local Hospitals were inspected. The club met for an afternoon program consisting of a talk by Dr. W. E. Morse on "Preventive Medicine and Surgery." Professor A. C. McIntosh of the state School of Mines, talked on "Water Supply of Various Cities in the U.S." and Superintendent R. E. Rich of the Methodist Hospital, talked on "Hospitalization."